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PRINTED ON THIN PAPER FOR FOREIGN CIRCULATION.


# ENGINEERING:

An Illustrated Weekly Journal.

*EDITED BY CHAS. COOPER AND J. FOSTER PETREE.*

TEMPORARY OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 18 & 20, COMPTON ROAD, HAYES, MIDDLESEX.

VOL. 152—No. 3948. *LONDON: FRIDAY, SEPTEMBER 12, 1941.* *Registered at the General Post Office as a Newspaper* PRICE 1s. BY FOREIGN POST 1s. 3d.



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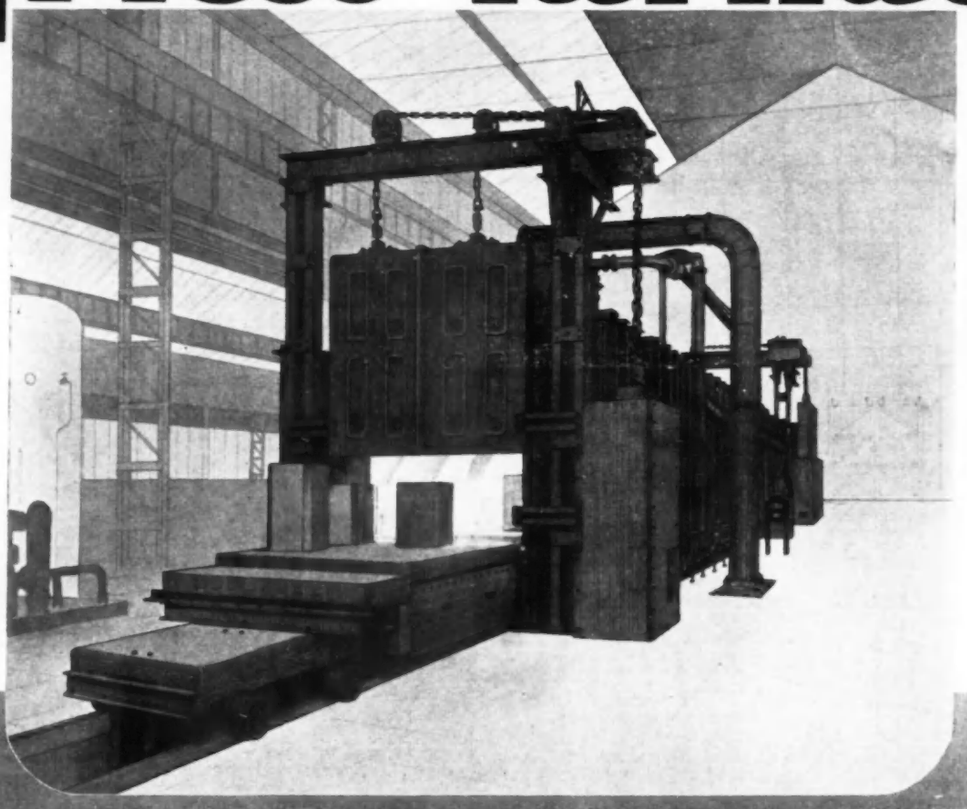

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941.

# TIMBER-DRYING KILN.*

SINCE the last issue by the Department of Scientific and Industrial Research of Leaflet No. 10 describing an overhead-internal-fan kiln developed at the Forest Products Research Laboratory, war-time conditions have called for the drying of considerably larger quantities of home-grown timbers. Freshly-felled softwoods containing a high percentage of moisture must now be dried in ever increasing quantities, and in as short a time as is possible. The kiln as originally designed has proved very suitable for drying most hardwoods even from the green state, but it was felt that there was room for improvement if the kiln were to be used extensively for the drying of green softwoods. In drying such woods, it becomes necessary to provide ample means for ridding the system of the large quantities of moisture that must be continuously extracted from the timber, and the benefits to be derived from periodic reversals of the direction of air movement are appreciable. The kiln herein described incorporates most of the features of that described in the edition above referred to, but includes certain modifications which make it more suitable for the drying of green softwoods.

After extensive experience with various types of kilns, the Laboratory is of the opinion that the overhead internal-fan kiln represents one of the most efficient and economical types at present available. The fact that all the equipment (fans, heating pipes, etc.) are carried overhead makes for cheap construction, reasonable accessibility, immunity from flooding and ease of loading. There are, however, several varieties of the overhead internal-fan kiln, and the one to be described is itself only a variation of the general type. The Laboratory is of the opinion that, in this type of kiln, the width of the timber pile through which the air circulates should not exceed 6 ft. With one set of fans and the double-pile system of loading, a kiln with minimum equipment and maximum loading space is obtained.

Fig. 1. LONGITUDINAL SECTION

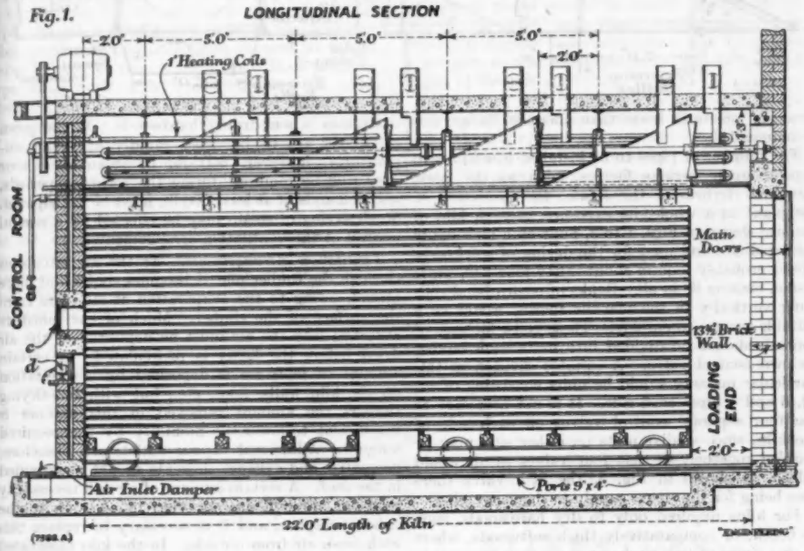



Fig. 2.

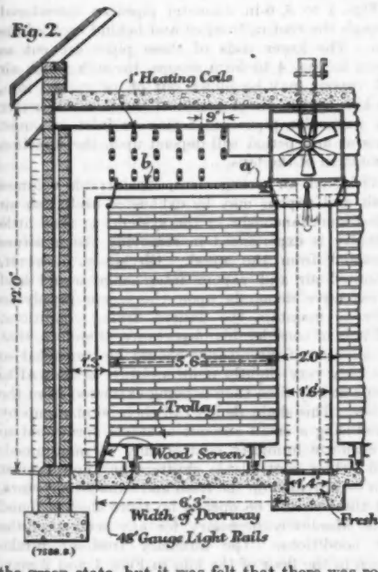
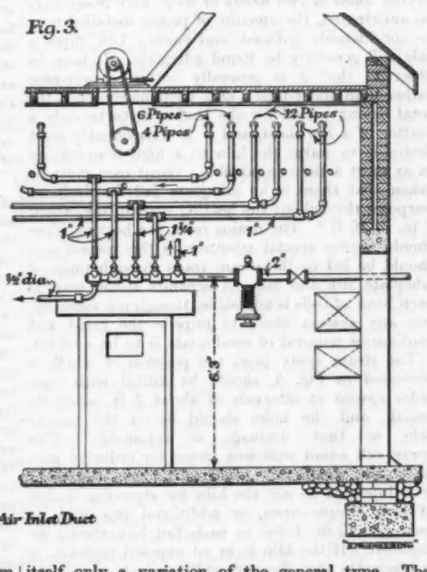



Fig. 3.




Drawings of the kiln are reproduced in Figs. 1 to 5, on this page and on page 202, and the construction is described below. Although the kiln may appear complicated, it should be noted that it consists entirely of standard engineering components. There are, of course, alternative and equally successful ways of carrying out the details of construction, and moreover, there are many minor points with which it has not been found possible to deal in the pamphlet referred to. In case of doubt, therefore, and where additional information is required, the Laboratory should be consulted. Inquiries on the subject should be addressed to the Director, Forest Products Research Laboratory, Princes Risborough, Aylesbury, Buckinghamshire. A drying kiln of the type described can be inspected at the Laboratory by appointment.

*Dimensions of the Kiln Shell.*—Since the width of the timber stack—in the direction of the air path—should not exceed 6 ft., the maximum overall width of the compartment must not exceed two stack widths plus the space required for the inlet and outlet air ducts, *i.e.*, 16½ ft. Fig. 2 is a part cross section of a kiln with two stacks, but it should be borne in mind that by dropping one or other of the canvas curtains indicated at *a*, the kiln, although built for two piles, will operate efficiently with only one stack. Where the demand for dry timber is variable, this may be a valuable feature. The height between the bottom of the timber stack and the false ceiling *b* should not exceed 8 ft., while the distance between the top of the stack and the ceiling should not be less than 9 in. It is quite practicable to reduce the height of the kiln, or to dry a pile of timber of less height than will fill the kiln, provided that the unused space is blanked off with curtains to prevent the circulating air from short-circuiting over the stack. As a general rule, the inlet duct, or space between the pile and the wall, should be 15 in. wide, and the width of the outlet duct below the fan boxes should be about the same as the fan diameter.

It has been found convenient to place the fans at intervals of 5 ft., although small deviations from this are unimportant and will depend on the number of fans required, which, in turn, depends on the length of kiln most suitable for the stock usually handled. In this pattern of kiln a space of 2 ft. must be left between the ends of the stacks and the doors, and for this reason where kilns less than 12 ft. long are required, other patterns are more economical of space. The type illustrated in Fig. 1, however, is quite suitable for lengths between 12 ft. and 22 ft. Provided that the heating coils are arranged so as to ensure an adequate fall for drainage, kilns of this pattern may be constructed up to 42 ft. in length. If the length exceeds 42 ft., trouble may be experienced in obtaining uniform conditions throughout, although the Laboratory has not had the opportunity of confirming this. In any case, a special layout of the heating coil feed and drainage would be necessary.

*Construction of the Shell.*—Concrete is the best material for the kiln floor and for the wall footings. Small gutters should be cast in the floor to carry away any water accumulating during the drying process. The walls may be built of brick, and ventilated cavity construction is recommended. Eleven-inch walls are satisfactory (two single bricks with 2-in. air space), but if the outer skin is of 9-in. brickwork, there is better heat insulation. The usual damp courses should be specified. The top can be made of reinforced concrete or of hollow tiles; in either case, provision for thermal expansion should be made. The kiln top should be covered with a light roof, to protect it, the air outlets, motor, etc., from the weather, and to enable further insulation, such as sand or sawdust, to be spread on the top. Although brick and concrete are very convenient materials for kiln construction, wood, asbestos, metal, etc., can also be employed. The essential qualities are: sufficient strength, reasonable resistance to moisture, and heat insulation.

*Doors.*—Side-hung doors with heavy stiles and rails cannot be recommended, as they will warp and drop in a comparatively short time. The essentials of kiln door construction are flexibility, lightness of weight and tightness of fit. To avoid undue stresses on hinges and walls, the door should not be wider than necessary. Experiments at the Laboratory have demonstrated the enormous loss of heat resulting from badly fitting doors. Air-leaks around the doors may cause difficulties in kiln operation, and poor insulating properties result in local cooling, with excessive condensation. A door found to give satisfaction in service is one made of sheet metal suitably protected from corrosion on the inside and insulated on the outside. It is

* Leaflet No. 10 (Revised Edition) entitled *Timber Drying Kilns; The Overhead Internal Fan Kiln*, by W. C. Stevens, M.A., A.M.I.Mech.E., and D. D. Johnston. Issued by the Forest Products Research Laboratory, Department of Scientific and Industrial Research. Abridged. Crown copyright reserved.

relatively flexible and is hung at the centre. Clamps are provided at intervals round the edges, so that the door may be pulled up hard against the jambs. The joint between door and jamb is a face joint and should be provided with felt strip about ¾ in. wide, which should be greased with tallow to prevent the door from sticking and the paint from flaking. The door frame is of 4½ in. by 4½ in. timber. Doors of the type that drop into tapered slots and press against the jambs under their own weight should give satisfaction, but may require slots and pins additional to those usually supplied, if a really good contact is to be obtained.

*General Internal Layout.*—All the "working parts" of the kiln (fans, fan boxes, shafting, heating pipes, etc.) are hung from joists running across just underneath the ceiling. These joists also function as guides or deflectors in sending the air from the fans across instead of along the kiln. Baffles of this description are absolutely essential, and if the joists are arranged in some other fashion to that shown in Fig. 1, wooden or other baffle boards at least 8 in. deep must be provided. The importance of this cannot be too greatly stressed; unless there are baffles to direct the air from the fans across the kiln, the circulation through the timber stacks will not be uniform. This location of the joists in the relative positions shown on the drawing is strongly recommended, and the hangers for the shaft bearings and steam pipes can, if preferred, be attached to them by dogs or cleats, thus obviating any necessity for drilling the joists. The walls immediately under the joists should be solid and not cavity, and formed with piers 18 in. wide.

*Fans, Shafting and Bearings.*—If placed as suggested at intervals of about 5 ft., the fans should be at least 24 in. in diameter. For general purposes they should run at about 800 r.p.m., and at this speed each fan should have a free air delivery of about 5,000 cub. ft. per minute. They should be designed so as to work with equal efficiency in either direction of rotation. The fan shafting must be stiff, say, from 1½ in. to 1¾ in. in diameter, and the bearings, of ball or roller type, must be totally enclosed and self-aligning. Provision should be made for lubricating with a high melting-point grease, and the "grouped nipple" system centralised outside the kiln is convenient. These bearings should be placed at intervals along the length of the shaft of not much more than 5 ft.

Thermal expansion of the shafting is allowed for by locking only one bearing, that nearest the belt pulley being the most convenient for the 22-ft. length, and if direct drive is employed a flexible coupling should be fitted between motor and shaft. With a kiln of the size shown in Figs. 1 to 3, a 2-h.p. reversing motor, running at 1,500 r.p.m., is sufficient, *i.e.*, about ½ h.p. per fan. This relation may be used as a guide in designing a compartment of another size. The advantage of small variations in speed are slight, and it is unnecessary to use a direct-current motor on this account. In view of the wider choice of position for mounting the motor, belt drive is preferable to direct drive, particularly if a V-rope belt is used. Belt-tensioning gear should be provided.

*Fan Boxes.*—The fan boxes, seen in detail in Figs. 4 and 5, may be made of wood, but preferably of sheet metal of at least 16 S.W.G. In either case, they must be thoroughly coated with a moisture-resistant paint, and repainted at fairly frequent intervals.

*Heating Coils and Steam Sprays.*—Much latitude is permissible in the design of the heating coils, and plain or gilled pipes may be employed. Ordinary 1-in. steam piping and fittings may be used and have proved to be very satisfactory. If temperatures of 150 deg. F. and upwards are required, as is usual when softwoods are to be dried, it is advisable, wherever possible, to work with steam pressures of the order of 40 lb. to 60 lb. per square inch. It is always advisable to fit a reducing valve between the main supply and the feeds to the kiln, so that a steady pressure can be maintained, and, in fact, the kiln as a whole can, to some extent, be controlled by judicious manipulation of this valve. For temperatures lower than the above, and for the drying of refractory timbers, steam pressures as low as 10 lb. per square inch may be employed, but generally pressures lower than about 20 lb. are not recommended.

## TIMBER-DRYING KILN.

Fig. 4.

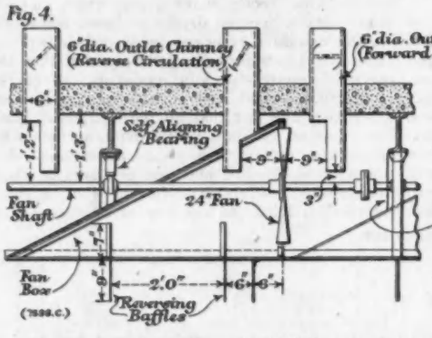
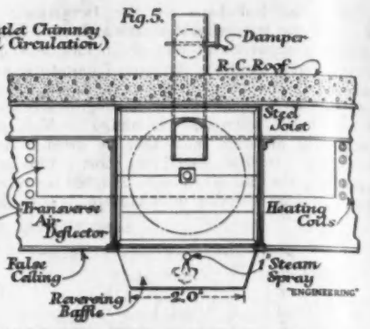



Fig. 5.




The number of pipes to be installed in a kiln will depend upon various factors, such as the pressure and dryness of the steam, the insulation of the plant as a whole, its exposure, etc. A kiln of the size shown in Figs. 1 to 3, built on a reasonably sheltered site and used for the drying of softwoods, would probably require about thirty-four 1-in. pipes a side, making 68 in all. Banks of return bend coils hung vertically in the manner shown, would be a suitable system to employ. These coils, for ease of control, should be divided into units each having its own control valve. A suitable division in this particular instance would be units consisting of 12, 12, 6 and 4 pipes each side. It is not necessary to use four separate control valves on each side of the kiln, since similar units on either side may be coupled together, so that four valves in all would suffice, as shown in Fig. 3, the fifth valve there seen being for the steam supply to the spray pipe.

For kilns required only to dry hardwoods, such as beech, or comparatively thick softwoods, where drying times of two weeks or more may reasonably be anticipated, the amount of piping installed may be considerably reduced, and twenty 1-in. pipes a side will generally be found adequate. It may be observed that it is generally better to over-pipe rather than under-pipe a kiln, particularly when the total drying period for the timber is to be only a matter of a few days, and it is consequently most desirable to warm the kiln to a high temperature in as short a time as possible. Great care must be taken that there is an adequate fall for drainage purposes throughout the heating system, say, about ¾ in. in 10 ft.* The drains from the heating pipes should receive special attention in this respect and should be led to the steam traps through pipes of adequate size and fall. A separate steam trap to each bank of coils is advisable, though not essential, but any system likely to impede the rapid and continuous removal of condensate is to be avoided.

The steam spray pipe, the position of which is indicated in Fig. 5, should be drilled with ⅛-in. holes spaced at intervals of about 2 ft. along its length, and the holes should be on the underside so that drainage is automatic. This spray will admit sufficient steam for ordinary purposes, but where very rapid warming is desired or it is intended to use the kiln for steaming timber at high temperatures, an additional pipe with at least four ⅛-in. holes to each fan box should be installed. If the kiln is in an exposed position, it is advisable that the end wall, against which the last fan blows, should be warmed by a few lengths of pipe running across the kiln and connected to the smallest heating-coil unit.

*Steam Consumption.*—No precise information can be given on the amount of steam likely to be required, as so much will depend on the construction adopted, the timber being dried, weather conditions, etc. However, a reasonably well built double-sided kiln about 22 ft. long should seldom require more than 200 lb. of steam per hour under normal conditions when drying hardwoods. When green softwoods are to be dried rapidly at high temperatures, however, 600 lb. of steam per hour may well be required during the warming periods, and demands of at least 500 lb. must be anticipated. Much saving of steam may be effected by a careful control of the ventilation arrangements.

*Ventilation Arrangements.*—As the air circulates through the timber pile, it becomes cooler and more humid, owing to the evaporation of moisture from the surface of the timber. Much of the moisture absorbed into the air must be deposited or the air dried before the latter is recirculated. A certain amount of moisture is deposited by condensation on the kiln walls, floor, etc., but with free-drying timbers the amount removed in this manner is insufficient to lower the humidity by the required amount. Additional vapour outlets are, therefore, necessary, and exhaust air vents should be provided in the roof. A certain amount of air will necessarily pass out through any air vent in addition to the exhaust vapour, and it is necessary to replace this with fresh air from outside. In the kiln illustrated in Figs. 1 to 3, 6-in. diameter pipes are introduced through the roof in front of and behind each of the fans. The lower ends of these pipes are cut as shown in Fig. 4 to form scoops, through which air and vapour may be blown out of, or sucked into, the kiln by the direct action of the fans. Whether any particular pipes are acting as inlet or outlet vents at any period will depend upon the direction of rotation of the fans.

With such an arrangement, considerable volumes of air and vapour may be exhausted and fresh air added simultaneously to the system, so that little difficulty is experienced in removing the moisture extracted from the wood. Obviously, however, unlimited air and vapour interchange would lead to excessive demands upon the steam supply in order to maintain the desired drying conditions, and it is of considerable importance, therefore, that the amount of interchange should be controlled so that only very slightly more moisture is allowed to escape at any time than is being extracted from the timber. This slight deficit can then be made up by introducing a small amount of steam spray and so an accurate humidity control may be maintained. Well fitting controllable shutters or louvres must then be provided on the fresh and exhaust air vents, and these should be opened no more than is found to be absolutely necessary for any setting of the kiln conditions. The auxiliary fresh-air intake shown in the floor of the kiln in Figs. 1 and 2 may, if required, be used for forward circulation in the place of, or in addition to, the fresh-air intake pipes in the roof.

*Reversal of Air Circulation.*—In passing through a pile of timber air becomes colder and wetter, as it moves from one side to the other. In consequence, timber situated near the side where the air leaves the pile tends to dry more slowly than that situated near the side where the air enters. If the drying of the load as a whole is at a comparatively moderate rate, and the air speed between the rows is reasonably fast, there will not be a great difference in the two drying rates, and at no time will the moisture content differences across the width of the pile be large. Such conditions usually exist when hard-

* In a 42-ft. kiln of this type rather more headroom between the roof and false ceiling will be required to obtain adequate fall than is necessary in the case of the 22-ft. kiln depicted.

woods or semi-refractory timbers are being dried, and a short "conditioning" period at the end of the drying period will usually produce a uniform moisture content throughout. When, however, a fast-drying green softwood is to be dried, the moisture-content differences between one side of the pile and the other may well become excessive, and it is then usually found to be expedient to reverse the direction of air flow for a period. By doing this, the incoming air now comes immediately into contact with the wetter portions of the pile, and, as a consequence, their drying rates are accelerated.

For normal running with the air moving in what is termed the forward direction in a kiln of this type, the air is blown outwards to the walls and after passing through the piles returns to the fan boxes by way of the central duct. Most propeller-type fans work with equal efficiency in either direction, and to reverse the air flow, therefore, it is necessary only to reverse the direction of rotation of the motor. Simple transverse baffles of the kind shown in Figs. 4 and 5 must be fitted across the fan boxes to ensure that a more or less uniform distribution of air is obtained when reversal of the air flow is deemed to be necessary. Without these baffles the air will move in a lengthwise direction along the central duct, and an excessive quantity will pass through the piles at the far end of the kiln, while little or none will get through the piles at the end near the doors. It should be noted that the air flow is appreciably more uniform in the so-called forward direction, and the circulation should only be reversed if, and when, it is shown to be necessary by considerable difference in the drying rates at the two opposite sides of the piles.

*Protective Coatings.*—The brickwork and concrete should be protected from corrosion and made as waterproof as possible by a coating of bituminous or other suitable paint. Similar attention should be given to the doors and other metal and woodwork in the kiln. Heating pipes should be preserved with a heat-resisting paint, such, for example, as aluminium paint.

*Methods of Piling the Timber.*—Boards and planks should be piled longitudinally and horizontally and, as far as possible, edge to edge. Piling-sticks should be set across the timber, in vertical alignment, at 18-in. to 3-ft. centres, depending on the thickness of the timber. Very thin boards or timber liable to warp badly may require shorter distances between sticks. For material up to 1-in. in thickness, sticks ½ in. thick and 1 in. wide are suitable, but for thicker material sticks 1 in. square are preferable. The sides of the piles should be kept as straight as possible. Any projecting piece of timber will be liable to deflect the air in such a way that the layers of timber immediately above will receive more, and the layers below less, than their fair share of the air.

It should be realised that it is desired to dry the timber primarily from the surface, and not from the edges and ends. Thus edge to edge piling will result in the air passing between each layer and drying the top and bottom surfaces of the boards or planks. If gaps are left between the edges of adjacent planks the air will tend to move vertically through the pile, and this may cause eddies and stagnant patches. Furniture parts, such as rails, squares, etc., can often be self-crossed; that is to say, pieces of the timber can be used instead of piling sticks, though in the case of short length stock, it is advisable to interpose a few piling sticks running the full width of the pile to tie the stack together.

*Gauging the Progress of Drying.*—The only satisfactory way of assessing the drying rate is by weighing sample pieces built into the timber pile, such pieces being representative of the load as a whole and exposed to similar drying conditions. As the drying rate is bound to vary from one side of the pile to the other, it is as well to employ several samples, at any rate until the operator has become familiar with the peculiarities of the kiln, since no two kilns are exactly alike. Simple tests and calculations, which have been frequently described, enable the moisture content of the sample pieces to be determined initially. Re-weighing the pieces provides data from which the current moisture content can be calculated. The samples should be built into the piles in positions where the drying may be expected to be fastest and where slowest.

By reducing the thickness on the under-side of the piling sticks where they bridge the samples and supporting with blocks on one or both sides if considered necessary, the samples can be withdrawn at any time without disturbing the pile as a whole. It is better to cut the sticks above the samples, rather than those on which they rest, as the air space over and below will then remain the same as for the rest of the timber. Sample pieces should be as long as convenient and certainly not less than 5 ft. when the bulk of the load is of this length or longer. In the case of dimension stock, the sample pieces should be exactly similar to the rest of the load and where "self-crossing" is employed, slightly undersized pieces may be chosen as samples, so that the adjacent pieces will take the weight of the pile above.

*Temperature and Humidity Control.*—To indicate the temperature and humidity in the kiln, one or more wet and dry bulb hygrometers will be required. The simplest form of hygrometer, consisting of two mercury-in-glass thermometers mounted side by side, can be strongly recommended. The wet and dry bulb type of hygrometer is the only one that can be relied upon for use in timber-drying kilns. The thermometers should be placed in an inlet duct and are best read through a port *c* in one end of the kiln, Fig. 1, using a focusing torch or spot light to illuminate them, indicated at *d* in Fig. 1. It should be remembered that if the circulation of air is reversed, the original outlet duct becomes the inlet and the control thermometers must be transferred to this duct or a second set must be available. The temperature is controlled by regulating the amount and pressure of the steam admitted to the heating coils, and the humidity by adjusting the supply of steam to the spray pipe and to a less extent by opening and closing the fresh and exhaust air dampers.

## LITERATURE.

*Surge Phenomena. Seven Years' Research for the Central Electricity Board* (1933-1940). London: The British Electrical and Allied Industries Research Association. [Price 50*s.* net.]

THIS lavishly produced volume contains an immense amount of material in the form of surveys of the existing knowledge in different branches of the subject and the results of experiments and investigations carried out by the Electrical Research Association. In a foreword, the Director of Research, Mr. E. B. Wedmore, explains the origin of this undertaking and points out that it took his Association some years to show that it was able to render effective service to industrial undertakings by scientific examination of the uncertain aspects of problems which were involved in new developments and to secure adequate financial support for the purpose. It was the recognition by the Central Electricity Board that the E.R.A. offered facilities for organised research, he states, that led the Board in 1933 to invite the Association to submit proposals showing what profitable work it could undertake of immediate interest to the Board. This was done, and, on the advice of their engineers, the Board agreed to make such a contribution to the funds as would enable the Association to pursue certain proposals on an adequate scale.

These proposals related to the study of surge phenomena, including ascertainment of the surge properties of the actual grid circuits, the workinh characteristics of available types of lightning arresters and surge absorbers, and the plant used therewith. This part of the research involved the development of much special experimental apparatus of a portable kind suitable for field work. The E.R.A. proposed also to make a comprehensive study of the effects of surges on power transformers in relation to the design of the windings and inter-turn insulation. The Association represented also that there were many gaps and uncertainties in knowledge relating to the behaviour of dielectrics and of cables under surge conditions, and that progress in this field was necessary if the designer was to rise above the level of empiricism and mere trial and error.

The report consists of five parts, comprising in all 25 chapters. Part I consists of a study of lightning, and contains five chapters. The nature of lightning is first considered and it is suggested that, while the charge neutralised in a lightning flash is probably 50 per cent. greater than has hitherto been believed, the cloud potential is only a few per cent. of the accepted value, and the energy of the flash no more than about 250 kWh, as compared with Wilson's value of about 2,800 kWh. Graphs show the current in lightning flashes to transmission lines as recorded in tests by a number of independent observers. The magnetic and radiation field changes caused by lightning are discussed. A graph is given of the current in transmission line towers due to a lightning flash, and a series of recommendations is made for further work. The technique of recording by means of the Klydonograph is described, with an account of an investigation of certain features of voltage surges on transmission lines; a work which has been going on for six years and is still in progress. Measurements by means of "magnetic links" are given, for obtaining data on the magnitude of lightning currents in tower structures. An investigation is now in progress involving some 12,000 towers on the South Lincolnshire Ring. Links were also used during 1938 and 1939 in Nigeria, and an account of these tests is given. The point discharger is considered in Chapter 4, this appliance having been used for the qualitative study of the earth's electrostatic field near the ground level during the lightning season of 1939 in Nigeria.

Part II, on surge propagation, opens with a theoretical study of the differential equations for wave transmission. Solutions are given for infinite and finite lines and the effect of earth currents is evaluated for a number of typical cases, including multi-conductor systems. This chapter concludes with an investigation of corona discharge, and a theory is advanced to account for observed phenomena. In connection with the generation and recording of controlled surges, details are given of the surge generator and cathode-ray oscillograph equipment, including the potential divider. A description of tests on the attenuation and distortion of surges on a typical 33-kV double-circuit line, with earth-wire protection, is followed by a study of the propagation of waves above and below the corona voltage of the line, as well as chopped waves, the results being compared with the theories previously developed.

Chapter 9 is concerned with the attenuation and distortion of impulse waves, both below and above the corona limit, for the case of the 132-kV Reading-Portsmouth line of the Central Electricity Board. A comparison is made between the modification of the waves as actually measured and the results predicted from theoretical considerations. This is followed by a description of tests on the 132-kV Leicester-Corby line, for the purpose of investigating various travelling waves above and below the corona, with special reference to the effects of an additional earth wire. An account is given of experiments in which the resistance of soil contained in a tank, is deduced from the volt-ampere characteristic, the soils considered being a sandy gravel and a puddle clay.

Surge voltage distribution in transformers is the subject of Part III, the first chapter of which deals with the theory of the phenomena occurring in a uniformly distributed transformer winding when a rectangular travelling wave reaches a line terminal. Mathematical formulæ are developed for the initial voltage distribution and for the subsequent oscillations, neglecting the attenuating effect of the resistance. The effects of various departures from the assumptions made, both as regards the wave shapes and the winding characteristics, are considered. Various methods for minimising transient effects are discussed. Chapter 13 deals with inter-turn insulation of transformer windings and their ability to withstand the effects of surge voltages. The need for reinforcement of the insulation between turns adjacent to line terminals or winding discontinuities has long been recognised. A mathematical analysis is given to show that the efficacy of reinforced end turns insulation is limited, the analysis being quantitative as far as the available

data permit. A brief summary of the theory of surge-voltage distribution introduces typical test results in the form of oscillograms and voltage distribution curves, and a comparison is made between the calculated and experimental values for the essential characteristics. Conclusions are drawn regarding the truth of the general theory, and the protection provided by static end-rings. Chapter 15 provides a résumé of published information on the fundamental principles of the transference of impulse voltages between transformer windings, dealing mainly with loaded transformers. Calculations based on the application of rectangular waves are given, and effects of other forms of waves are also discussed. Theoretical solutions are given for surges applied to one or both ends of a single-phase transformer and to one, two or three line terminals of a three-phase transformer.

Part IV examines the effects of surges on solid dielectrics and the conditions necessary at breakdown in order that the measurements shall give the electric strength of the material under test. The influence of electrode shape and immersion medium are discussed and the results of impulse tests at voltages up to 700 kV are given. A separate chapter deals with the effects of surges on cables. The puncture voltage of high-tension cables with oil-impregnated dielectric has been determined for impulse voltage stresses. The tests comprised cables with circular and elliptical conductors, as well as belted cables. The effects of wave-shape, polarity, and repeated stressing are discussed, together with the results of visual examination, and a value is given for the puncture impulse strength of the impregnated paper insulation. Other matters considered in this part of the book are the effect of surges on insulators and associated gaps, and the flash-over voltage of different wave-shapes; the relation between maximum voltage and time to flash over at voltages above the minimum required for flash-over; the simultaneous application of impulse and alternating voltages; and the I.E.C. proposals for over-voltage tests on single insulators.

Part V deals with protection against surges. The methods in common use are outlined and detailed descriptions are given of individual devices, including those which are only suitable for use on low-voltage circuits. A critical survey is given of the theoretical and experimental work carried out to determine the protective ranges of lightning rods, and is extended to cover protection of transmission lines by earth wires. A fundamental criticism is given of methods employed in tests with models. A laboratory study is reported of the operating characteristics of several lightning-protective devices, including arresters, flash-over protectors, and devices for modifying the wave shape. Eleven arresters, covering a range of 6 kV to 50 kV, three absorbers (33 kV to 132 kV), and three types of flash-over protectors were tested. Specifications for lightning arresters are also discussed. Chapter 22 describes tests on a surge absorber, various protective gaps, and lightning arresters for 33 kV and 11 kV, carried out on a 33-kV grid line. The effects of these devices when connected either on the incident side or at a point beyond the actual point to be protected were examined. The chapter on the E.R.A. surge filter deals first with wave modification by means of impedances and then describes its development, design, and performance, and gives a mathematical study of its operation. Chapter 24 contains a report from the National Physical Laboratory on the filter and its behaviour at prospective voltages up to 550 kV, and compares it with other protective devices. The concluding chapter summarises the methods and apparatus available for the protection of overhead transmission lines and associated installations against the effects of surges, with recommendations covering the cases commonly occurring in practice.

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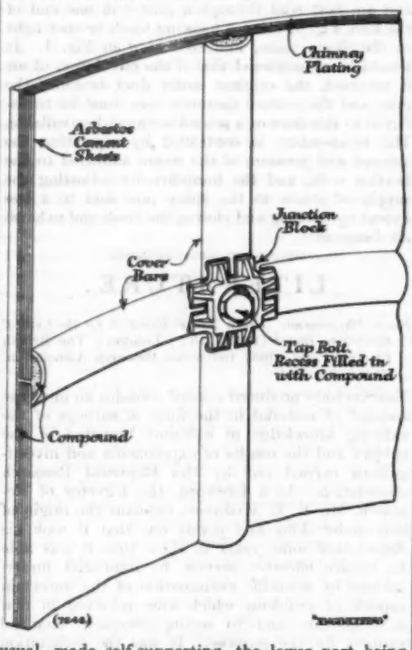
GENERAL LICENCE FOR MACHINE-TOOL USERS.—Under the provisions of S.R. & O., 1941, No. 1164, (price 1d.) dated August 6, a general licence is issued permitting the supply, without Board of Trade licence, of electrical machinery and plant of the type specified in Class 53 of the Schedule to the Machinery, Plant and Appliance (Control) No. 4 Order, 1941 (S.R. & O., 1941, No. 1063, price 1d.), when they are to be employed in connection with, or as part of, machine tools.

# THE PREVENTION OF CORROSION IN STEEL CHIMNEYS.

By A. V. STANIFORTH, A.M.I.Mech.E., M.I.Struct.E.

IN the last 20 years, developments in the size and efficiency of boiler plants have led to the abandonment of huge masonry chimneys serving a number of boilers in favour of a separate chimney for each boiler. This has been brought about not only for the sake of the obvious advantages accruing during overhaul and repair from such sectionalising, but also because the very large units of to-day call for much larger chimney areas, which would make a common chimney for several units a massive and expensive structure; also, the natural development of placing the chimney over the boiler structure, to avoid reversal of the flow of gases, premises that the chimney should be as light as possible in weight. The need for steel chimneys, therefore, followed naturally, and, as these have been used with reasonable satisfaction for a long period, no special difficulties were anticipated.

The normal chimney was built of lapped, riveted plates, either guyed for stability, or, as became more




usual, made self-supporting, the lower part being stiffened either by gusset brackets to a large base-plate or by increasing the diameter towards the base. With the improvement of boiler efficiency, the temperature of gases at exit to the chimney was lowered, and from this time the difficulties previously experienced on a small scale became serious.

It was found that corrosion took place inside chimneys and connecting ducts at a very rapid rate, and, at one large power station, five steel stacks, each 7 ft. 6 in. in diameter by 80 ft. high, constructed of ⅜-in. mild-steel plates riveted together, had corroded away in parts to paper thickness in five years. This corrosion had developed in spite of annual internal and external cleaning and painting. An investigation showed that, in all cases, the corrosion had become most serious at, and had undoubtedly started from, the joint laps and rivet heads; further, that the defects were most serious in the upper part of the chimney. It was also found that there was frequently a considerable quantity of water in the chimney bases. The temperature of the gas entering the chimneys was about 250 deg. F., at which the steel temperature, particularly near the top of the chimney, often fell below dew point, especially during the colder periods of the year. This caused deposition of moisture (sometimes increased by rainfall), and this, combining with the sulphurous gases, formed sulphurous acid which attacked the steel. The moisture running down the chimney naturally collected along the joint laps and rivet heads, and thus was responsible for the especially severe corrosion at these points.

In solving the problem, it was therefore considered desirable, firstly, to eliminate the focal points of corrosion, *i.e.*, the lapped joints and rivets; and, secondly, to find some type of lining which, while not interfering with the fundamental characteristics and efficiency of the steel chimney, would afford adequate protection to the steel plates. Modern developments in electric welding provided the answer to the first part of the problem, as, by its use, welded butt-joint chimneys are easily constructed, thereby giving a smooth, parallel barrel free from all foci for corrosion.

Protecting the interior of the chimney plates from corrosion presented three difficulties for solution. These were: firstly, to obtain a suitable material to provide an inner protective lining, which had to be cheap, light and readily formed to circular or other shapes; secondly, to discover a compound to fill the space between the back of the lining and the steel plates of the stack; and, thirdly, to devise a satisfactory method of securing the lining in position. Asbestos-cement sheeting of certain types provided a ready solution to the first difficulty, although, in the earlier stages of experimenting, some trouble was occasioned by the asbestos absorbing the oils from the compound and by cracking of the sheets. These difficulties have now been overcome. The production of a suitable compound gave the chemists a difficult task, as it was decided that, if the solution was to be effective, it must not only be a good protective medium for the steel, but must remain permanently plastic even with temperatures ranging up to 600 deg. F., and must not at any stage become hard or fluid. After considerable research, a satisfactory compound was made and this has been used very successfully.

The final problem, of providing cover bars over the joints to hold the asbestos-cement sheets in place, while at the same time sealing the spaces between adjacent sheets, presented a corrosion problem of its own. An early attempt at a solution by using non-ferrous metals was not satisfactory, due primarily to the lack of mechanical strength of the metal used and the fact that even these metals were attacked by the corrosive influences. The non-ferrous metal strips were replaced by steel flats secured by steel studs, the flats and the heads of the studs being sand-blasted and sprayed with non-ferrous metals. A greater measure of success was obtained, although it was found that the non-ferrous metal sprayed on the steel was destroyed in about 12 months, particularly near the top of the chimney. Both the abovementioned methods were relatively expensive, and were not sufficiently permanent to provide a real solution.

In the examination of the problem, cast iron had often been considered, as being a cheap metal, readily shaped to give adequate strength and yet very resistant to corrosion; but this had been eliminated from the discussion owing to difficulties of application and the risk of the bars breaking during the flexing of the chimney under wind and other stresses. Eventually, however, cast iron provided the solution, and the patented system now in operation and shown in the accompanying illustration makes use of an articulated form of cover bars. These cover bars are of arcuate section, and in lengths of about 2 ft., at each end of which is cast a semi-circular lip stiffened by a rib. The ends of the bars engage under cast-iron junction blocks, having projecting lugs with which the semi-circular lips engage. The junction blocks are secured to the stack by means of steel studs, the heads of which are recessed in the block. To prevent corrosion of the stud heads, the recess is filled with compound. With this arrangement, as the cover bars are not fixed at the ends, but are free to slide under the influence of chimney stresses, and can pivot on the rounded ends of the lips during chimney movement due to wind, there is no tensile stress on the cast iron. Also, the side of the cover bar next to the asbestos sheets forms a hollow space,

which is filled with compound, thus effectively sealing all joints in the lining.

The system of chimney protection described has been used with success in a number of power stations and other installations. The five steel stacks previously mentioned were replaced by lined stacks in 1935 and, in 1940, a section of lining was removed from one of the stacks. It was then found that no corrosion of any kind had taken place and that the mill-scale was still on the steel.

One great advantage of this type of chimney treatment is that, as the lining and compound together are only ⅛ in. thick, the effective diameter of a chimney is not materially reduced; while the weight of the lining, complete with compound, sheets and cover bars, increases the total weight of the chimney by only one-third in the case of a ¼-in. steel-plate construction. New foundations are therefore, not necessary when existing stacks are replaced. Another advantage is that the insulating effect of the lining cuts down the heat loss, and, therefore, the period during which the temperature of the steel falls below dew point is very much reduced. Tests showed that, with a gas temperature of 290 deg. F., the outside temperature of an unlined stack was 210 deg. F., while the lined stack had an outside temperature of 150 deg. F. The lower outside temperature of the stack reduces considerably the cost of maintenance of the outside of the chimney by increasing the life of painting.

During the past six years, many lined chimneys at power stations and commercial plants have been installed with most satisfactory results. These stacks range from 12 ft. down to 2 ft. in diameter, the latter size being lined with asbestos-cement tubes instead of segmental sheets.

## LEDLOY LEAD-BEARING STEELS.

On page 381 of our 147th volume (1939), we gave an account of the properties and applications of Ledloy lead-bearing steels, the principal advantage of the lead addition being that the machinability of the steel is greatly improved without impairing its mechanical properties, response to heat treatment, or fatigue resistance. We also stated that no technical details regarding the manufacturing process were then available for publication and that the amount of lead present was apparently of the order of 0·20 per cent. A good deal of additional information on the utility and properties of Ledloy steels, and some interesting data regarding their manufacture, have been given recently by Mr. W. B. Wragge, a director of Messrs. Ledloy, Limited, Woodley, near Stockport, Cheshire, in a lecture to the personnel of one of the Sheffield steel firms. With regard to the amount of lead present in the steels, Mr. Wragge stated that considerations of machining performance and manufacturing economy determined that the optimum lead content, for commercial purposes, for steels made by open-hearth methods, lay between 0·20 per cent. and 0·30 per cent.

In the course of the lecture, results of numerous tests were given, the main object of which was to emphasise that the addition of lead left the mechanical characteristics of the steels virtually unchanged. Consequently, it was stressed that the influence of the addition of lead to steel differed from that of the addition of other elements, such as phosphorus, nitrogen and sulphur, which had adverse effects on certain mechanical characteristics. Some particularly interesting results were contained in a report issued by the Research Department, Woolwich, and entitled "The Effect of Lead on the Transverse Tensile Properties of Steel." From tests made in the Department's machinability tester it was found that the effect of lead on the machinability of a steel was far more marked when cuts were taken in a direction at right angles to that of the rolling operation than when they were taken longitudinally. Consequently, it was thought possible that the lead might have some deleterious effect on the mechanical properties measured in a transverse direction. Tensile tests were therefore made in two directions on a series of steels, three of which contained lead and three of similar composition which were lead free. The composition of the steels is given in Table I. As the bars furnished were only 1⅛ in. in diameter the tests were made with a Hounsfield Tensometer, using a test piece 0·02 sq. in. in cross-sectional area for the first four steels of the series and one of 0·01 sq. in. area for the two higher-carbon steels, since the tensile strength of these two steels, as measured on a larger test piece, was beyond the capacity of the Tensometer. Some typical results are given in Table II, and, from these, the report concludes that "it is clear that the presence of lead has no harmful effect on the transverse properties of the steels tested."

Series of tests carried out by Messrs. Ledloy, Limited, on lead-bearing alloy steels were given in detail in the course of Mr. Wragge's lecture. It was stated, for example, that additions of 0·17 per cent. to 0·20 per cent. of lead to a 3 per cent. nickel case-hardening steel (B.S.S. No. 3 S. 15) and a 3½ per cent. nickel steel (B.S.S. No. S. 69) gave a combined improvement in machinability, when in the normalised or annealed condition—as expressed by a "sawability" index and

TABLE I.

| Element. | Research Department Designation. | | | | | |
|---|---|---|---|---|---|---|
| | SRS | SRT | SRU | SRW | SRX | SRY |
| C per cent. .. | 0·12 | 0·12 | 0·45 | 0·43 | 0·55 | 0·59 |
| Si " .. | 0·08 | 0·10 | 0·125 | 0·14 | 0·245 | 0·225 |
| Mn " .. | 0·53 | 0·64 | 0·60 | 0·62 | 0·84 | 0·85 |
| S " .. | 0·015 | 0·01 | 0·02 | 0·01 | 0·01 | 0·015 |
| P " .. | 0·03 | 0·025 | 0·035 | 0·035 | 0·025 | 0·025 |
| Pb " .. | Nil | 0·24 | Nil | 0·23 | Nil | 0·23 |

TABLE II.

| Steel. | 0·2 per cent. Proof Stress. Tons per sq. in. | Maximum Stress. Tons per sq. in. | Elongation. Per Cent. | Reduction of Area. Per Cent. | Vickers Diamond Hardness (30 kg. Load.) |
|---|---|---|---|---|---|
| SRS—L* .. | 16·0 | 28·0 | 40 | 65 | 118 |
| SRS—T* .. | 16·0 | 27·5 | 32 | 55 | |
| SRT—L .. | 16·5 | 27·7 | 45 | 67 | 116 |
| SRT—T .. | 17·5 | 27·5 | 35 | 55 | |
| SRU—L .. | 25·0 | 45·5 | 25 | 42 | 190 |
| SRU—T .. | 25·5 | 45·0 | 15 | 28 | |
| SRW—L .. | 24·5 | 40·0 | 35 | 55 | 165 |
| SRW—T .. | 23·5 | 39·0 | 25 | 40 | |
| SRX—L .. | 27·5 | 54·0 | 22 | 40 | 225 |
| SRX—T .. | 27·0 | 51·0 | 12 | 22 | |
| SRY—L .. | 28·0 | 53·0 | 20 | 40 | 222 |
| SRY—T .. | 27·0 | 47·0 | 15 | 20 | |

* L = Longitudinal; T = Transverse.

a drilling index—of 47 per cent. in the case of the 3 per cent. nickel steel and of 42 per cent. in that of the 3½ per cent. nickel steel. The influence of the addition of 0·17 per cent. of lead to a nickel-chromium-molybdenum oil-hardening steel was also investigated. This material had the following percentage composition: carbon, 0·41; manganese, 0·74; silicon, 0·22; sulphur, 0·023; phosphorus, 0·013; nickel, 1·73; chromium, 0·65; and molybdenum, 0·33. In the normalised or annealed condition, the lead-bearing steel is stated to have shown an improvement in machinability—again as derived from sawing and drilling tests—of 37 per cent. The corresponding improvement for oil-quenched and tempered specimens was 21 per cent. Similar tests were conducted on austenitic 18/8 stainless steel, lead-bearing stainless steel, and selenium-bearing stainless steel. One-inch diameter bars of each material were turned in a lathe using a high-speed steel tool having a top rake of 15 deg. and a front clearance of 10 deg. No cooling medium was used and the maximum cutting speed was 130 ft. per minute, the depth of cut 0·125 in., and the feed per revolution 0·001 in. The power used in the tests was determined and converted into horse-power per cubic inch of metal removed per minute. This figure was 1·88 in the case of the plain 18/8 steel; 1·20 in that of the lead-bearing 18/8 steel, and 1·09 in that of the selenium-bearing 18/8 steel.

The corrosion-resisting properties of Ledloy steels were investigated at the Research Department, Woolwich. The steels, analyses of which are given in Table III, were obtained in the form of rods, 1 in. in

TABLE III.

| Element. | Ledloy Free-cutting Steel. | Ledloy Mild Steel. | Mild Steel. |
|---|---|---|---|
| C per cent. .. .. | 0·11 | 0·15 | 0·19 |
| Si " .. .. | < 0·01 | 0·08 | 0·09 |
| Mn " .. .. | 0·74 | 0·56 | 0·78 |
| S " .. .. | 0·27 | 0·01 | 0·10 |
| P " .. .. | 0·10 | 0·03 | 0·10 |
| Pb " .. .. | 0·27 | 0·24 | Nil |

diameter. Test pieces, 3 in. long by 0·9 in. in diameter, were prepared by machining, and finishing with emery. Microscopic examination of polished sections showed, in the Ledloy free-cutting steel, a normal structure containing sulphide inclusions elongated along the length of the rod. No marked inclusions were observed in the Ledloy mild steel. A number of specimens of the lead-bearing steels were Parkerised. Three forms of corrosion test were applied. Some of the specimens were exposed for one month to the outdoor atmosphere at University College, Swansea. A second batch of specimens were sprayed with sea water for one month, once a day, indoors; while a third batch was exposed to a damp atmosphere for one month. They were stored in a wooden box fitted with a watertight lid and kept indoors. As a result of these tests it was concluded that the difference in corrosion resistance between the Ledloy and the ordinary steels was small. The lead-free mild steel, of moderately high sulphur and phosphorus content, corroded a little more than the Ledloy free-cutting steel on outdoor exposure, but a little less under damp storage conditions. It is emphasised, however, that further tests of longer duration would be required to confirm these favourable results. Parkerising on machined surfaces was found to be unaffected by the presence of lead in the steel.

It is stated that statistics are incomplete with regard to the effect of lead on the corrosion resistance of stainless steels, but standard methods of measurement indicate that lead-bearing steel stands up rather better than lead-free steel. Some work has also been done in connection with corrosion fatigue and a report on work done on two steels at the National Physical Laboratory shows that the endurance limits, on a 50-million cycles basis, of these two materials were ±4·4 tons and ±5·2 tons per square inch. No data regarding the steels are given, it being merely stated that both have a carbon content of 0·42 per cent. and a tensile strength of approximately 40 tons per square inch, and that the second (that having an endurance limit of ±5·2 tons per square inch) is designated by the letters Led. The fatigue tests were carried out in rotating-beam type machines, at a speed of about 2,200 stress cycles per minute. A fine spray of 3-per cent. common salt solution was blown on to the test portions of the specimens by means of compressed air.

The concluding portion of Mr. Wragge's lecture was concerned mainly with the manufacture of Ledloy steels. He stated that a high pouring temperature was desirable and that the lead should be added, at a uniform rate, in the form of shot ranging from 0·020 in. to 0·040 in. in diameter. The lead should not, however, be added until the mould has been filled to from one-fifth to one-quarter of its capacity. It was emphasised that the presence of lead in a lead-bearing steel did not and could not overcome machining difficulties attributable to the presence of segregates at the core, of high slag content, or of abrasive inclusions of the alumina type. Microscopically, a normal unetched specimen of leaded steel showed no evidence of the lead and while researches were still proceeding into the development of a suitable etching medium to reveal the lead, the best method now available for indicating its presence appeared to be to use a hot sodium sulphide, sodium picrate mixture. The majority of the lead present in a leaded steel probably existed in the free metallic form, but under certain conditions a small proportion might be partially associated with sulphide inclusions.

The handling of lead-bearing steel in the steel plant presented no major difficulties other than that of the necessity of removing lead-oxide fumes in cases in which this might be evolved in quantities likely to be injurious to the health of the employees. Up till the present, no case had been reported of an employee having been subjected to a toxic concentration, so that the existing methods of removing lead fumes appeared to be entirely efficient. Lead-bearing low-sulphur steels, as now manufactured, did not cause any difficulty in the blooming and subsequent rolling operations. It had been stated, however, that the sulphur and lead-bearing free-cutting steels showed rather increased "tenderness" in the first operations of cogging, but that this difficulty could be overcome by increasing somewhat the soaking-pit temperature.

It was difficult to lay down stringent rules for the optimum speed of pouring casts of steels, as conditions varied widely from plant to plant. It was obvious however, that the adoption of a wide-diameter pouring nozzle gave a rate of steel flow so rapid as to cause difficulties in maintaining a uniform and efficient addition of the lead. One steel firm advocated the use of 1½ in. to 1⅝ in. nozzles when pouring 3½-ton ingots, and another stated that satisfactory results were obtained by using 1½ in. to 1¼ in. nozzles when pouring 2¼-ton ingots. The remelting of lead-bearing scrap, ingot tops, etc., had presented no difficulties, the makers stating that there was no evidence that furnace arches, bottoms, the region at the slag line, or the chequer work, had suffered sufficiently to cause comment. It was confirmed that in the remelting of the scrap, the lead content was almost completely volatilised as lead oxide, so that the material could be used for the manufacture of lead-free casts without any fear of contamination.

GOLD PRODUCTION IN NORTH-WEST CANADA.—The Canadian Department of Mines and Resources reports that gold is being produced in increasing quantities in the North-West Territories of the Dominion. The output for the first six months of 1941 was 31,001 oz., compared with 24,799 oz. in the first half of 1940.

# HIGH-SPEED "CARBICUT" LATHE.

MESSRS. ALFRED HERBERT, LIMITED, COVENTRY.

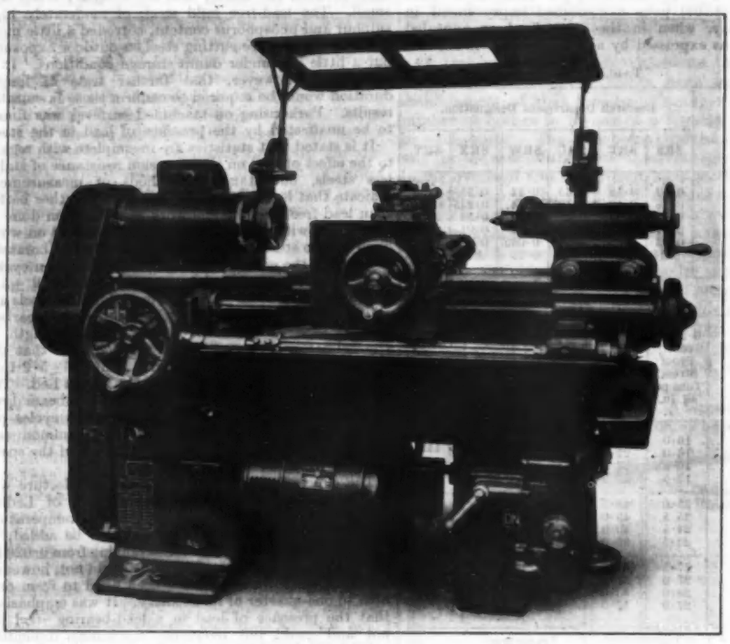


FIG. 1. FRONT OF LATHE.

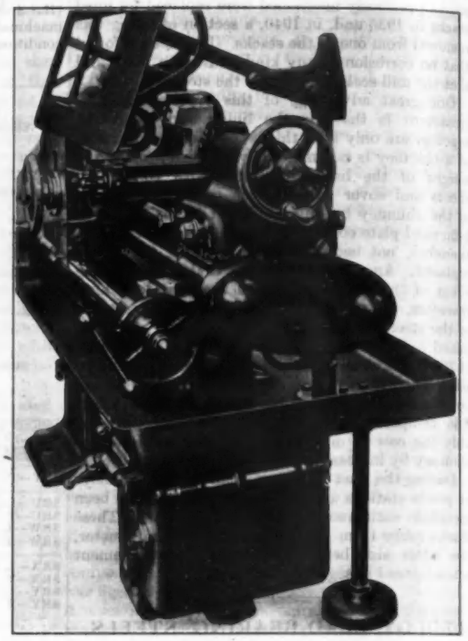


FIG. 2. END VIEW SHOWING REAR TOOL-POST.

## HIGH-SPEED "CARBICUT" LATHE.

THE somewhat unusual-looking centre lathe illustrated on this page has been designed by Messrs. Alfred Herbert, Limited, Coventry, for the machining of shafts ranging from ¾ in. to 2½ in. in diameter and having a maximum length between centres of 22 in., such shafts usually having several parts of different diameter in their length, though plain parallel shafts can, of course, be turned equally well. The main reason for the introduction of this new lathe is that a higher degree of accuracy is obtainable by means of the single tool cutting at high speeds it employs than can be secured with hexagon turret lathes or with multi-cut lathes. The closer limits of accuracy and concentricity naturally result in savings on subsequent grinding operations. The lathe, which is known as the Herbert Patent "Carbicut" Lathe, is intended for use with Ardoloy or other high-speed cutting alloy tools and its design and construction incorporate the practice employed in the firm's range of small high-speed motor-driven capstan lathes.

Referring to Fig. 1, it will be realised in the first place that the machine is entirely self-contained, the two-speed driving motor being mounted under the bed on the left hand leg in which there is a speed-change box. The whole of the electrical contactor gear, main isolating switch and fuses are contained in a cabinet in the right hand leg, the door of which cabinet is connected to the isolating switch in such a manner that the switch cannot be closed until the door is shut. An analogous safety device is provided for the left-hand cabinet, the operator being protected, when changing the pick-off gears, by the fact that the electrical supply is cut off as soon as the cabinet door is opened. The electrical equipment is arranged for a supply at 400 volts to 440 volts, three-phase, 50 cycles. A no-volt release is incorporated to prevent the machine from being re-started, should the current fail, until the push-button seen on the right hand cabinet is pressed. The push-buttons visible on the headstock are for the selection of the fast and slow speeds of the motor and for stopping the machine. The speed-change buttons, which also function as starting buttons, can be operated to make a change while the machine is running, the instantaneous changes thus secured being in the ratio of 1·5 to 1. Smaller diameters can, therefore, be turned at the higher speed. When stopping the machine the spindle is brought to rest, almost instantaneously, by an electrical plugging relay.

The base of the machine is formed with three-point support to eliminate special levelling during installation, the only work thus necessary on the site being connection to the electrical supply. The bed is hardened by the makers' Flamard process so that the ways, the contour of which is seen in Fig. 2, have a Brinell hardness of between 478 and 555, a high degree of resistance to wear being thus ensured. Maximum stiffness and the largest possible chip clearance space are provided by diagonal bracing through which the swarf falls to the tray below. The saddle is fitted on one side with covers in contact with, and sliding on, the ways of the bed. The speed-change box in the left-hand cabinet is provided with pick-off gears on splined shafts, special retaining washers on the ends of the shafts enabling the gears to be changed in a few seconds. Transmission from the gearbox to the spindle is by means of multiple Vee-belts the tensioning of which is effected by turning the gearbox, the belt pulley being mounted eccentrically. There are 16 spindle speeds altogether, the slow range varying from 445 r.p.m. to 1,990 r.p.m. and the fast range from 676 r.p.m. to 3,025 r.p.m. The spindle is mounted in the headstock on two double-purpose ball bearings at the front end and on one roller bearing at the rear end, and these bearings require only occasional greasing to maintain the original accuracy and to ensure long life. The spindle nose is provided with a conical centre and a work carrier having three-screw adjustment covering the full range of diameters from ¾ in. to 2½ in. The construction of the driver will be clear from Fig. 2, and of the carrier from Fig. 4 (*a*), on the opposite page. When changing similar work pieces no spanner is required, one of the adjusting screws on the carrier being inserted in a slotted plate attached to the machine and the work itself being used as a lever to slacken or tighten the screw. The slotted work-driver ensures quick insertion of the work on the centre, with safety.

The saddle carries a cross slide fitted with a square turret holding facing, undercutting and chamfering tools at the front, and a "Chipstream" tool-post holding a turning tool, at the rear. The form of this post is evident in Fig. 2. It carries an Ardoloy tangential turning tool mounted at an angle to give the desired front and side clearances and having the cutting face on the end of the tool. A setting block is supplied for adjusting the tool to the correct height. Since the tool will make cuts up to ¼ in. deep, and the rate of rotation of the work is high, the operator would be subjected to danger from flying chips if certain provisions to eliminate it were not made. These provisions consist of a patent chip breaker fitted to the rear tool-post to break the turnings into short lengths and a swinging guard with armour-plate glass windows. The chip breaker is not readily distinguishable in Figs. 1 and 2, but the nature of the guard will be clear from them. The saddle has hand longitudinal traverse and a quick power traverse, in both directions, of 200 in. per minute, this latter motion being engaged by a finger-controlled lever situated at the right-hand end of the machine and moved in the direction in which saddle traverse is desired, an arrangement reducing the time required to run the saddle back from shoulder to shoulder after making turning cuts.

The quick power longitudinal traverse is derived from an independent fractional horse-power motor, transmission being by belt to the end of the traversing and feed screw. The hand traverse is effected by a handwheel which is locked electrically with the quick power traverse in such a way that before this latter can be engaged the handwheel must be pulled outwards and is therefore not rotated, otherwise a dangerous high speed of the wheel would be attained. The feed traverse towards the headstock is derived from a feed box driven from the main spindle by a flat belt. Three rates of feed traverse are provided, viz., 70 cuts, 105 cuts and 140 cuts per inch, the coarse feed being that generally used. The changes are obtained by manipulation of a lever on the feed box, the feed being engaged or disengaged by the ball-ended lever seen behind the handwheel at the headstock end of the machine in Fig. 1. In this figure the shaft seen below the feed screw is a rotatable hexagonal stop-bar for use when

TABLE I.—EXAMPLES OF WORK DONE ON "CARBICUT" LATHE.

| Position in Fig. 3. | Material. | Length. In. | Largest Diameter. In. | Floor to Floor Time. Min. |
|---|---|---|---|---|
| Top left | Air-hardening nickel-chrome steel | 15 | 2·25 | 15 |
| Middle left | Air hardening nickel-chrome steel | 19·625 | 1·375 | 14 |
| Bottom left | 0·75-per cent. to 0·58-per cent carbon steel | 18 | 1·625 | 18 |
| Top right | 0·38-per cent. to 0·45-per cent. carbon steel | 6 | 1·75 (shank) | 4 |
| Middle right | 0·38-per cent. to 0·45-per cent. carbon steel | 10·25 | 1·125 | 8·5 |
| Bottom right | Air-hardening nickel-chrome steel | 7 | 1·375 | 7·5 |

# HIGH-SPEED "CARBICUT" LATHE.

MESSRS. ALFRED HERBERT, LIMITED, COVENTRY.

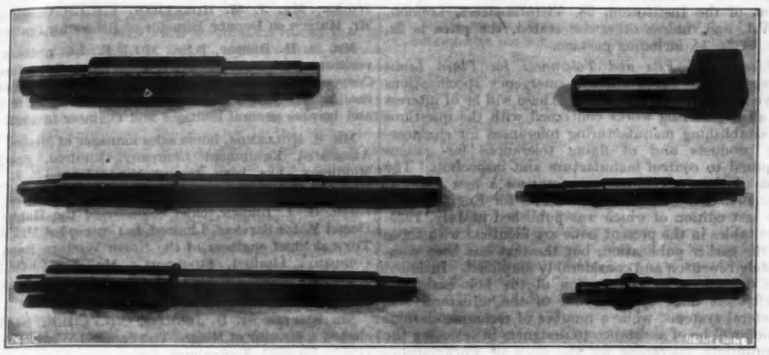
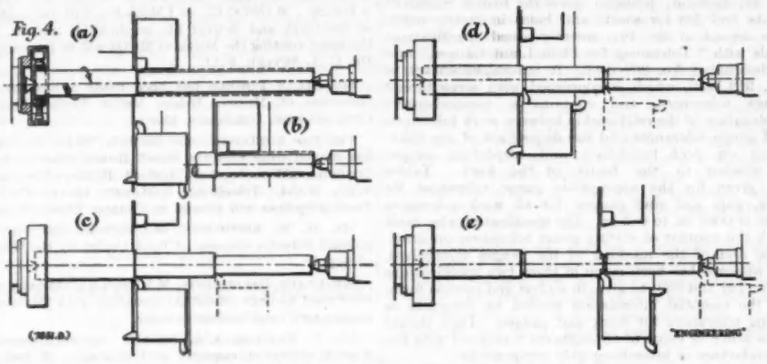


FIG. 3. TYPICAL PARTS PRODUCED ON LATHE.




lengths are required to be accurately duplicated. A dead stop is also provided and is used in conjunction with the traversing handwheel which has a device for regulating the degree of pressure on the stop, so conducing to accuracy. The cross slide of the saddle has hand adjustment only, and its traversing screw is fitted with a micrometer dial graduated in divisions of 0·002 in. Accurate duplication of diameters is obtained in either direction by four rotatable barrel stops on the cross slide visible in Fig. 2. The tailstock calls for little comment, other than that it is of the firm's spring-loaded type which allows for expansion of the work due to heat and eliminates damage to the centre and its bearings, the latter being of the ball and roller type.

The tooling of the machine is simple so that the setting-up time is reduced to a minimum. A typical tool set-up for a shaft having three diameters is shown in Fig. 4. In this figure view (*a*) shows the first turning cut by the tangential tool on the rear post, the cut being indicated by dotted lines. In view (*b*) the saddle has been moved back and a second cut for a smaller diameter on part of the shaft has just been made. The square turret is idle in these two operations. In view (*c*) the turret has been advanced to the work and the tool-post retracted. The turret is shown in two positions with a tool for facing the shoulders so that precise lengths of the portions of different diameters are obtained. In view (*d*) the turret has been rotated and traversed to undercut the shaft at the two shoulders, while in view (*e*) further rotation, with appropriate traverse, enables one shoulder and the small end of the shaft to be chamfered. Six examples of work actually done on the "Carbicut" lathe are shown in Fig. 3, above, particulars being given in Table I, on the opposite page.

TABLE II.—*Recommended Cutting Speeds for Steel Bars. Feed, 70 Cuts per Inch.*

| Material. | Depth of Cut. | | |
|---|---|---|---|
| | ¼ in. | ½ in. | ¾ in. |
| | Ft. per min. | Ft. per min. | Ft. per min. |
| Carbon Steels :— | | | |
| 0·1 per cent. to 0·18 per cent. carbon | 700 | 750 | 800 |
| 0·25 per cent. to 0·35 per cent. carbon | 500 | 650 | 700 |
| 0·38 per cent. to 0·50 per cent. carbon | 450 | 500 | 600 |
| 0·75 per cent. to 0·85 per cent. carbon | 300 | 350 | 400 |
| Carbon-Chromium Steels :— | | | |
| 0·4 per cent. to 0·5 per cent. carbon<br>0·7 per cent. to 1·0 per cent. chromium | 350 | 400 | 450 |
| Special Tool Steel :— | | | |
| 0·90 per cent. to 1·10 per cent. carbon<br>1·20 per cent. to 1·60 per cent. chromium | 200 | 250 | 300 |
| Nickel-Chrome Steels :— | | | |
| 3·75 per cent. nickel-chrome, air-hardening | 400 | 500 | 600 |
| 1·5 per cent. to 2·0 per cent. nickel-chrome, oil-hardening | 300 | 400 | 500 |
| 3·0 per cent. to 4·0 per cent. nickel-chrome, case-hardening | 450 | 550 | 750 |

The tables specify lengths of parts ranging from $\frac{1}{16}$ in. to 100 in., in steps of $\frac{1}{16}$ in. up to 2 in. long, and after that in steps of $\frac{1}{8}$ in. to 20 in. long. Beyond 20 in. the tables advance in 5 in. and 10 in. stages. The 26 tables cover 3, 4, 5, 6 and 7 off, then jump to 80 off and advance by units to 100 off. By moving a decimal point, or combining tables, the lengths required for other numbers off may be found. The tables, the construction of which obviously represents a laborious amount of arithmetic, should save much computation in say, stores and purchasing departments. It would appear, however, that they must be used with discretion. They show that if 99 parts, each 70 in. long, are to be manufactured, and that if 5 per cent. allowance is made, then 606·375 ft. of material will be required. If this is an extruded section, it will not be delivered in one piece 606·375 ft. long, and the problem of the storekeeper is to work out the best length of bar to order, or, if it is available only in fixed commercial lengths, to ascertain and allow for the necessary wastage. It may be that the allowances made are sufficient to cover this, and the fact that it is stated on the title-page of the brochure that the tables have been compiled for use by the Bristol Aeroplane Company, suggests that they have been found of practical value. The association of this company's name with the tables, also indicates that the expression of the bar lengths in decimals of a foot, up to eight places for the shortest length, has been found a convenience. To one who has not used the tables, it appears that for practical purposes 73·734 ft. might well have been set down as 73 ft. 9 in.

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CONTROL OF EXPORTS TO JAPAN.—The Board of Trade has issued the Export of Goods (Control) (No. 27) Order, 1941 (S.R. & O. 1941, No. 1201, price 1d.), prohibiting, as from August 15, all exports to Japan, including Karafuto Japanese Mandated Islands, Korea, Kwantung Leased Territory, Formosa and Manchuria, except under licence from the Board of Trade. All outstanding export licences for these destinations have been revoked.

## NOTES ON NEW BOOKS.

*Material Tables for Wire, Bar and Drawn or Extruded Sections.* Weston-super-Mare: Lawrence Brothers (Weston-super-Mare), Limited. [Price 12*s.* 6*d.*]

THIS publication consists of a series of 26 tables giving the total length of bar which is required to manufacture specific numbers of parts of known length. Two bar lengths are given for each length of part, one making an allowance of 5 per cent. for cutting-off and machining, the other of 10 per cent. As an example, the table covering the manufacture of 91 parts shows that if each part is $11\frac{7}{8}$ in. long, and an allowance of 10 per cent. is made, then 99·057 ft. of bar will be required. The tables specify lengths of parts ranging from $\frac{1}{16}$ in. to 100 in., in steps of $\frac{1}{16}$ in. up to 2 in. long, and after that in steps of $\frac{1}{8}$ in. to 20 in. long. Beyond 20 in. the tables advance in 5 in. and 10 in. stages. The 26 tables cover 3, 4, 5, 6 and 7 off, then jump to 80 off and advance by units to 100 off. By moving a decimal point, or combining tables, the lengths required for other numbers off may be found. The tables, the construction of which obviously represents a laborious amount of arithmetic, should save much computation in say, stores and purchasing departments. It would appear, however, that they must be used with discretion. They show that if 99 parts, each 70 in. long, are to be manufactured, and that if 5 per cent. allowance is made, then 606·375 ft. of material will be required. If this is an extruded section, it will not be delivered in one piece 606·375 ft. long, and the problem of the storekeeper is to work out the best length of bar to order, or, if it is available only in fixed commercial lengths, to ascertain and allow for the necessary wastage. It may be that the allowances made are sufficient to cover this, and the fact that it is stated on the title-page of the brochure that the tables have been compiled for use by the Bristol Aeroplane Company, suggests that they have been found of practical value. The association of this company's name with the tables, also indicates that the expression of the bar lengths in decimals of a foot, up to eight places for the shortest length, has been found a convenience. To one who has not used the tables, it appears that for practical purposes 73·734 ft. might well have been set down as 73 ft. 9 in.

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*The Oil Engine Manual.* By D. S. D. WILLIAMS, A.M.I.A.E., and J. MILLAR SMITH, B.Sc. Second edition. Published for Temple Press Limited. London: The English Universities Press Limited. [Price 7*s.* 6*d.* net.]

THIS convenient manual, which appeared first in September, 1939, is intended to present the main principles of design and operation of the stationary oil engine in the same general manner as *The Motor Ship Reference Book* has dealt with the marine oil engine for the past 17 years. It consists of three sections and an appendix. The first section discusses in general terms the working of the oil engine and the broad divisions into types, with notes on starting systems, pressure-charging, lubrication, and maintenance. In the second part, descriptions are given of the principal British types of industrial horizontal and vertical engines, with some discussion of power-station layouts and a chapter on tractors and transportable engine units. The third section deals with oil engines for transport purposes, and contains separate chapters on engines for road vehicles, rail traction, and aircraft, and Diesel motor cars. The appendix consists of notes and tables covering such subjects as engine calculations, electricity costs, fuel standards, Diesel fuels, standard specifications for oil engines, and operating costs of oil-engined road vehicles, together with various "Useful Facts and Figures" and a list of British manufacturers of oil engines. The text is concise and practical, and is adequately illustrated. We understand that the book has been adopted for instructional purposes in certain branches of the Royal Navy, the Army, and the Royal Air Force, as well as in the civil defence services, a purpose for which it appears to be well suited. Though some of the general arrangements are too small to be studied satisfactorily without a magnifying glass, the sketches of small details, which are numerous, are commendably clear and informative.

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THE LATE MR. P. HEDLEY.—Mr. Percy Hedley, who, we regret to state, died on August 27, at Carham-on-Tweed, Coldstream, Berwickshire, was chairman of Messrs. Walles Dove Bitumastic, Limited, manufacturers of anti-corrosive products, Collingwood Buildings, Newcastle-upon-Tyne, 1. This firm, which was incorporated as a limited company in 1899, was established by Messrs. E. F. Walles and E. J. Dove, as an offshoot of the firm of Messrs. John Dove and Company, Roman-cement manufacturers, founded in 1854. Mr. Hedley was a director for some years before being appointed chairman.

## ABRASIVE MATERIALS IN THE UNITED STATES.

THE Bureau of Mines, United States Department of the Interior, has recently issued a report on the production of artificial abrasives in that country. From this it is apparent that it is practicable to increase domestic production by about 50 per cent. over the output of 1940 without building new plants, while, from the nature of the industry plant capacity can be expanded rapidly if necessary. It is stated that, with the exception of industrial diamonds, the United States could attain self-sufficiency in regard to all necessary abrasives even with a complete stoppage of sea-borne traffic. The investigation referred to in the report would seem to have been made in connection with the national defence programme and the point is made that the motor-car industry has, in recent years, consumed more than 35 per cent. of the total output of abrasives. Imports of artificial abrasives have been large and have greatly exceeded domestic production. These imports have come largely from Canada, and as the manufacture of crude abrasive material is relatively simple, being conducted in arc or resistance-type electric furnaces, which are partly dismantled after each charge, production of the crude materials now carried on largely in Canada could be transplanted to any of the hydro-electric power plants in the United States without prohibitive capital outlay or undesirable delay.

Such a course involves readily accessible supplies, and on this head it is stated that ample quantities of raw materials for producing artificial abrasives are available in the United States, even bauxite used in making fused alumina being mainly produced domestically, although that used in making aluminium is largely imported. Some manufacturers of fused alumina own bauxite deposits and are thus assured of an adequate supply. The position with regard to some natural abrasives is not so satisfactory. Not only industrial diamonds, but also crude corundum, certain kinds of pumice, tube-mill linings and pebbles, and special razor hones have been largely imported, so that actual or prospective curtailment of imports may give rise to certain difficulties. Only three of the abrasive materials regularly imported have come from the Axis Powers or from countries that have fallen into their hands, and it is fortunate that domestic materials may be substituted for these particular items. Industrial diamonds are the only abrasives that might eventually be listed as a strategic material as defined by the Army and Navy Munitions Board. Except for limited production in Arkansas and sporadic finds in the glacial drifts of Wisconsin and other States, natural diamonds have not been found in the United States and that country, in common with other industrial nations, must look mainly to South Africa for its supplies. Plant capacity to manufacture both coated abrasives and grinding wheels appears to be ample or to be capable of rapid expansion.

SNOW DAMAGE TO TELEGRAPH AND TELEPHONE SERVICES.—Some idea of the magnitude of the damage and dislocation caused to the telegraph and telephone services on the London and North Eastern Railway by the blizzard which occurred in North-Eastern England last February is revealed by the fact that the work of repair has only just been finally completed. Some 10,000 insulators and 4,000 miles of copper wire were required for the repairs, which have been carried out continuously since February, by the Engineer's Department of the Railway Company assisted by the military authorities.

THE LATE MR. S. H. HORGAN.—Mr. Stephen Henry Horgan, F.R.P.S., whose death occurred on August 31 at his home in Orange, New Jersey, U.S.A., was a pioneer of the half-tone process for reproduction purposes, and was 86 years of age. It is stated in *The Times* that Mr. Horgan was responsible for the first half-tone illustration ever printed in a daily newspaper and that this appeared in the New York journal *Daily Graphic* on March 4, 1881. This illustration was the culmination of a long period of hard work, but subsequently the success of Mr. Horgan's methods revolutionised the practice of newspaper and magazine illustration. It is to his credit that he gave his processes freely to the Press world without restrictive patents of any kind. He was for many years photo-mechanical editor of the *Inland Printer* of Chicago and his books, *Horgan on Half-Tone* and *The Photo-Engraving Primer* are still consulted as text-books on photo-mechanical processes and have been translated into 14 languages. The National Institute of Graphic Arts in America awarded him its Medal, an honour rarely accorded to a living man. In 1929 he came to England and, during his stay, was made a Fellow of the Royal Photographic Society. On March 4, 1931, a bronze medal, bearing a bas-relief of Mr. Horgan's profile and appropriate inscriptions, was struck to commemorate the 50th anniversary of the introduction of the half-tone process.

## BRITISH STANDARD SPECIFICATIONS.

THE following specifications of engineering interest have been issued by the British Standards Institution. Copies are obtainable from the Publications Department of the Institution, 28, Victoria-street, London, S.W.1, and, unless otherwise stated, the price is 2*s.* net, or 2*s.* 3*d.* including postage.

*Limits and Fits and Tolerances for Plain Limit Gauges.*—Two important war-emergency specifications have recently been published. These will be of interest to all engineering works concerned with the questions of establishing manufacturing tolerances for engineering products and of fixing tolerances for gauges required to control manufacture and inspection. The first of these specifications comprises a new issue of No. 164, entitled "Limits and Fits for Engineering," the last edition of which was published in July, 1924. The tables in the present issue are identical with those in the earlier publication, but the text has been completely rewritten and considerably amplified. Included are definitions in explanation of the hole-basis and shaft-basis limit systems and of the unilateral and bilateral systems, while a number of recommendations which will be of assistance to designers in selecting the appropriate tolerances for the class of workmanship and type of fit required, are also given. A supplement, in the form of a separate publication (price 1*s.* net or 1*s.* 3*d.* including postage), gives the British Standard limits and fits for shafts and holes in metric units. The second of the two recently-issued specifications deals with "Tolerances for Plain Limit Gauges," and is designated No. 969-1941. It is complementary to No. 919-1940, which is concerned with screw-thread gauge tolerances, and contains a comprehensive explanation of the relationship between work tolerances and gauge tolerances and the disposition of the tolerances on both workshop and inspection gauges in relation to the limits of the work. Tables are given for the appropriate gauge tolerances for plug, gap, and ring gauges, for all work tolerances from 0·0003 in. to 0·2 in. The specification also deals with the manner of stating gauge tolerances on drawings, and of the marking of the gauges themselves. An attempt has been made in these two specifications (Nos. 164 and 969) to give, in a clear and concise form, all the essential information needed by designers in fixing tolerances for work and gauges. They should thus prove of value to all engineers concerned with the manufacture of interchangeable components.

*Wire Rope for Kite-Balloon Cables.*—At the request of the Ministry of Aircraft Production, an addendum slip has just been issued to specification No. 3 W 6, dealing with flexible steel wire ropes for kite-balloon cables. In the addendum slip a new cable, to be known as K B 16, is provided for. It is 0·159 in. in diameter and is made up of three strands, each comprising seven wires. Copies of the slip may be obtained gratis from the Institution, by quoting the number, C. F. (AC) 8227, and enclosing a stamped addressed envelope.

## BOOKS RECEIVED.

*Machine Shop Practice. A Textbook for Ministry of Labour Trainees, Apprentices and Technical Students.* By W. C. DURNEY. London: Sir Isaac Pitman and Sons, Limited. [Price 7*s.* 6*d.* net.]

*Department of Scientific and Industrial Research. Road Research Laboratory.* Wartime Road Note No. 2. *Issued in Co-Operation with the Ministry of War Transport. Sources of Naturally-Coloured Chippings in Great Britain.* London: H.M. Stationery Office. [Price 6*d.* net.]

*United States Geological Survey.* Water-Supply Paper No. 872. *Surface Water Supply of the United States,* 1939. Part 2. *South Atlantic Slope and Eastern Gulf of Mexico Basins.* Washington: Superintendent of Documents. [Price 40 cents.]

*Shanghai Municipal Council. Report of the Commissioner of Public Works.* 1940. Shanghai: North-China Daily News and Herald, Limited.

WEST HARTLEPOOL TECHNICAL COLLEGE.—The prospectus of the courses available at the West Hartlepool Technical College has recently been issued. The College provides evening and part-time day and evening courses and prepares students for ordinary National Certificates in mechanical engineering, electrical engineering, naval architecture and building and for advanced National Certificates in mechanical engineering. Courses for the chemical and allied industries and in preparation for the matriculation and intermediate B.Sc. examination of London University are also held. The College, moreover, provides a post-secondary school standard full-time day commercial course. Classes commence on Monday, September 15.

## PERSONAL.

The Minister of Works has appointed MR. LOCKHART W. HUTSON, F.R.I.B.A., formerly Deputy Director of Bricks for Scotland, to be Director of Bricks in succession to MR. T. P. BENNETT, F.R.I.B.A., now Director of Works. MR. J. M. HONEYMAN, F.R.I.B.A., succeeds Mr. Hutson as Deputy Director of Bricks for Scotland.

MR. D. H. BISHOP, B.Sc., M.I.E.E., has resigned his position as general manager and engineer of the Dundee Corporation Electricity Department, on account of ill health. He joined the staff of the Department in 1901 and became general manager and engineer in 1922.

MR. S. HOLLANDS, home sales manager of Messrs. The Associated Equipment Company, Limited, Southall, Middlesex, has been temporarily "loaned" to the Ministry of Supply for special duties.

MR. G. J. BROWN, chief engineer of the Hants and Dorset Motor Services, Limited, has succeeded MR. H. N. TUFF as chief engineer of the North Western Road Car Company, Limited, Stockport. Mr. Tuff has been appointed chief engineer of the United Automobile Services, Limited, Darlington.

SIR WALTER ST. D. JENKINS, C.B., C.B.E., has been elected a director of Messrs. The Sentinel Waggon Works (1936), Limited, Shrewsbury.

The Institute of Fuel proposes to arrange a luncheon in October, following which MR. W. M. SELVEY, Wh.Sc., A.R.C.Sc., M.Inst.C.E., M.I.Mech.E., will be inducted as president and deliver his presidential address. At the same meeting the Melchett Medal will be presented to DR. C. A. SEYLER, F.I.C.

SIR ALLAN POWELL has been made a director and chairman of Messrs. Briggs Motor Bodies Limited, Chequers-lane, Dagenham, Essex.

THE GAS ADMINISTRATION SECTION, BOARD OF TRADE, has moved from Chapter Street House, Chapter-street, London, S.W.1. to New Oxford House, Bloomsbury Way, W.C.1 (Telephone, HOLborn 4311). The Gas Testing Section will remain at Chapter Street House.

MR. H. M. AINSWORTH, M.I.Mech.E., has been appointed Director-General of Tank Design by the Minister of Supply.

MR. CLAUD BARRINGTON, M.I.Mech.E., has been made chief road haulage officer in connection with the Government's new road-haulage scheme.

MR. T. H. CARR, A.M.I.Mech.E., has been appointed deputy electrical engineer and manager of Bradford Corporation Electricity Department.

MR. WILLIAM GLASS, A.M.I.Mech.E., works manager of Messrs. Johnson and Phillips, Limited, Charlton, London, S.E.7, has been elected a director of the Company.

The Ministry of Home Security has placed the services of PROFESSOR W. N. THOMAS at the disposal of the Russian Government for special work.

MR. W. A. TOOKEY, M.Inst.C.E., M.I.Mech.E., has been appointed a Deputy Director of Royal Engineer Equipment under the Ministry of Supply.

The Senate of London University have conferred upon DR. W. KER WILSON the degree of D.Sc. (Engineering) for original work carried out by him on aero engine-airscrew power plants. Dr. Wilson has been recently appointed research engineer in the Engineering Department (Engines and Airscrews) of Messrs. De Havilland Aircraft Company, Limited.

THE LATE MR. G. M. B. HILTON.—We note with regret the death, on September 3, of Mr. George Maxwell Brooke Hilton, chief engineer of outside sales to Messrs. Heenan and Froude, Limited, Worcester. He was born at Derby on April 25, 1880, and attended St. Ann's Church School and the Collegiate School in his native town, and finally St. Oswald's College, Ellesmere, Salop. In July, 1899, he was apprenticed to Messrs. A. Handyside and Company, Derby, and completed his pupilage from March, 1901, until 1903 with Messrs. H. J. Coles, Limited, Derby. On leaving Messrs. Coles he joined the Peninsular and Oriental Steam Navigation Company and, in November, 1905, passed his Board of Trade examination as second engineer. Mr. Hilton obtained his first-class Board of Trade certificate in March, 1907, and left the P. and O. Company in the following month to take up an appointment as boiler and engineering surveyor, first with the Law Accident Insurance Society, Limited, and afterwards with the United Legal Indemnity Insurance Society, Limited. In 1911 Mr. Hilton joined the staff of Messrs. Heenan and Froude, Limited, as technical sales engineer at their Manchester office, and in 1919 was attached to their London office for similar duties. It was in December, 1923, that he was made chief engineer of all the firm's outside sales organisations. He was elected an associate member of the Institution of Mechanical Engineers in 1908 and a full member in 1929. He became a member of the Institute of Marine Engineers in 1928.

## NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

*The Welsh Coal Trade.*—Reports current in the Welsh coal trade that the Government intended to transfer some 2,000 ex Welsh miners, now in other industries, to the Midland coalfields have caused a good deal of anxiety in the Welsh steam-coal market. News of this intention was received, together with the announcement that the Government were going to put into operation immediately compulsory powers to recruit ex-miners for the pits, the voluntary system having proved unsatisfactory. So far, about 2,900 men have answered the appeal to return to the pits, but this figure is still far short of South Wales' requirements. The position in the Midlands is understood to be even less satisfactory than in Wales and a transfer of certain of the labour which would now become available is stated to be imperative if the Midlands are to reach the quota required from it for the winter. There was again a brisk business offering on the Welsh steam-coal market during the past week. Inland buyers were still anxious to enter into heavy forward contracts, but with collieries still engaged almost to full capacity on fulfilling orders already in hand, the amount of new business that could be accepted for early delivery was extremely restricted while stem lists were already well filled to ensure the maintenance of present conditions over a short time ahead. As a result, the general tone was firm and what occasional parcels of the more favoured kinds sellers had to offer for early delivery were taken up at strong prices. Best large descriptions continued to move off steadily under existing commitments while the sized kinds were only sparingly available for a long time forward. A strong tone ruled among the bituminous small descriptions, which were well provided with business, but the inferior grades of dry steam smalls attracted only limited attention and, as supplies were readily obtainable, the tone was dull. Cokes were busy while patent fuel was quiet.

*The Iron and Steel Trade.*—Conditions in the tin-plate trade remained quiet owing to the restrictions, but the other branches of the iron and steel industries in South Wales and Monmouthshire displayed considerable activity and order books were well filled ahead.

## NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

*Iron and Steel.*—Efforts are being made in this area to collect more scrap. All kinds of metals are being sought, and a good tonnage is expected to accrue. In Sheffield the Corporation are expected to pull up several hundred tons of iron railings which surround public parks and recreation grounds and are located in front of certain buildings; it is hoped that owners of private property will follow their example. A quantity of iron girders, etc., is being salvaged from buildings damaged by enemy action. The general trade position has undergone little change. Pressure of business at the steel and engineering works continues to increase, and some firms have an accumulation of orders from commercial customers. When these will be executed it is impossible to forecast, as the demand for products for the Fighting Services is so heavy. Furnaces producing raw and semi-finished materials are operating at increased capacity, and producers are making every effort still further to increase their outputs. With this object in view, plans are under consideration for the installation of new electric and open-hearth furnaces. An increasing trade is being done in cold-rolled strip. Rolling mills, foundries, press shops, billet mills, and wire and rod departments are all handling larger outputs; machinery orders are also more numerous. The demand for steelworks' and ironworks' machinery and related equipment is developing on more extensive lines, among the plants in request being rolling mills, hydraulic presses, bending machines, steam hammers, electric and gas-fired furnaces. Mechanical excavators are in demand for various purposes, chiefly in connection with A.R.P. and building developments on Government account. Sheffield continues to do good business in plant for gold-mining enterprises in South Africa, Australia, and Canada. The call for grinding and crushing equipment, dredgers, washers, screens, steel balls, and machinery and tools has been well maintained. The season in agricultural equipment has been one of the best for many years; not only has trade been good on inland account, but sales to the Colonies and Dominions have reached a satisfactory level. All types of high-efficiency steels are in record demand and tool production is active.

*South Yorkshire Coal Trade.*—The inland demand for coal has increased considerably during the past few weeks; steelworks and ironworks are taking larger quantities and railway companies are building up stocks of locomotive fuel. Smalls and slacks are moving freely. Electric power stations and gas works are good customers. The house coal market is more active, as householders are laying in stocks for winter use. Foundry and furnace cokes are active.

## NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

*General Situation.*—The market is steady and iron and steel producers are dealing successfully with the large and increasing needs of customers having priority delivery claims, but have little tonnage for buyers of commodities for general commercial use. Imports from overseas have been curtailed to free shipping space for other commodities, but stocks and the increasing output of iron and steel are sufficient for essential requirements. Buyers engaged directly on war work are not desirous of placing extensive forward orders now that, under the control of distribution regulations, delivery allocations are sufficient for essential requirements.

*Cleveland Iron Trade.*—The continued activity at the foundries necessitates increased deliveries of pig iron, notwithstanding the unusually large use of scrap. The supply of Cleveland pig contributes little to the growing current needs and there seems to be no likelihood of much improvement in the make of local brands. Supplies from the Midlands and other producing areas, however, are ample for all needs. An increasing tonnage is coming under the control of merchants, who state, however, that the parcels in their hands are still insufficient fully to satisfy the requirements of regular customers. The fixed prices of Cleveland pig remain at the level of No. 3 quality at 128*s.*, delivered to local buyers.

*Basic Iron.*—The make of basic iron is ample for the heavy requirements of the local steelworks and provides a little tonnage for addition to the small emergency stocks. There is, however, little surplus for the market, and the quotation of 120*s.* 6*d.* is nominal.

*Hematite.*—The demand for hematite still considerably exceeds the supply, and there is no prospect of an increase in production. Under such conditions, new business is practically unheard of and deliveries are restricted to the essential requirements of licensed consumers. Wherever possible increasing use is made of refined iron in place of hematite, the stabilised values of which are ruled by No. 1 description at 138*s.* 6*d.*, delivered to North of England customers.

*Blast-Furnace Coke.*—Sellers of Durham blast-furnace coke have a heavy tonnage on hand, but have extensive running contracts and are not anxious to book further orders, while the needs of local users are as fully covered as is considered advisable. Business is quiet, but fixed prices are firm on the basis of good medium qualities at 36*s.* 9*d.* f.o.r.

*Manufactured Iron and Steel.*—Stocks of semi-finished iron and steel are substantial and as deliveries of local products are satisfactory, the temporary stoppage of imports from America is causing no trouble. Manufacturers of finished iron are busily engaged on the production of heavy commodities, but are only moderately employed in producing light descriptions of material. Steel producers have to keep most of their plant operating at full capacity to comply with customers' requirements. Sheet makers have a good deal of work to execute, but are booking a few new orders and structural steel producers are pressing sales, but the demand for other finished commodities continues. Ship, tank and boiler plates are in strong demand and priority is still accorded to shipbuilders' specifications. The consumption of special alloy steels calls for further increases in output.

*Scrap.*—Inquiries for all kinds of iron and steel scrap are increasing, and there is a continued pressure for larger deliveries of machinery metal, heavy cast iron and heavy steel.

TRAINING COURSES IN ELECTRIC WELDING.—Our readers may like to be reminded that Messrs. Murex Welding Processes, Limited, Waltham Cross, Herts., provide, in their welding school, three separate courses of instruction suitable for welding operators, technical foremen or supervisors, and designers. Both the supervisors' and the designers' courses are to a large extent theoretical. The courses are intensive in character and are intended to cover their separate fields in the minimum of time. Syllabuses are obtainable on application to the firm.

INDUSTRIAL DIAMOND REVIEW.—We have received three recent issues of a new supplement to *The Gemmologist*. This supplement, which is being published monthly, is called the *Industrial Diamond Review*, and it is devoted to a review of contemporary literature dealing with the use of diamonds, gem stones and hard materials as cutting tools, dies, bearings and abrasives in industry, and particularly their application to engineering. Original articles, correspondence and news items regarding these subjects are also included. The editor is Mr. Arthur Tremayne and the technical consultant Mr. Paul Grodzinski. The annual subscription is 5*s.* and the publishers are Messrs. N.A.G. Press, Limited, 226, Latymer-court, Hammersmith, London, W.6.

## NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTE OF METALS.—Wednesday, September 17, 2.30 p.m., 4, Grosvenor-gardens, Westminster, S.W.1. Thirty-Third Annual Autumn Meeting. (i) "Causes of Porosity in Tin-Bronze Castings," by Messrs. T. F. Pearson and W. A. Baker. (ii) "Unsoundness in Gravity Die-Cast Silicon-Aluminium Alloy Pistons," by Dr. R. T. Parker. (iii) "The Influence of Crystal Structure on the Cold-Rolling and Annealing of Copper Strip," by Drs. Maurice Cook and T. Ll. Richards. (iv) "X-Ray Examination of the Crystal Structures of Rolled Magnesium and a Magnesium Alloy," by Mr. D. E. Thomas.

INSTITUTION OF ELECTRICAL ENGINEERS.—*Installations Section:* Thursday, September 18, 6 p.m., Savoy-place, Victoria-embankment, W.C.2. Inaugural Meeting. (i) Address by the Chairman of the Section, Mr. H. T. Young. (ii) "Space Heating by Means of Electrically Warmed Floors, as Applied to Surface-Type Air-Raid Shelters," by Mr. R. Grierson.

## NOTES FROM THE NORTH.

GLASGOW, Wednesday.

*Scottish Steel Trade.*—The Government requirements for steel continue to absorb almost the whole of the output of the Scottish steelworks, and still less is available for other purposes. Production at the works is proceeding steadily, but in one or two directions the demand has diminished slightly. There is no falling off in the number of specifications for plates, etc., from shipbuilders. There is also a steady demand for plates for tanks and boilers, while structural sections are moving more freely and inquiries have improved. Light material generally is fairly active. In the black steel-sheet trade there has been little change and makers are well placed for business, especially for the thinner gauges. The raw material position is quite satisfactory, but a decided improvement in scrap collections will be necessary if production is to be maintained at the present high level. Steps are being taken to collect as large a tonnage as possible in order to augment present stocks. Prices are unchanged and are as follows:—Boiler plates, 17*l.* 12*s.* 6*d.* per ton; ship plates, 16*l.* 3*s.* per ton; sections, 15*l.* 8*s.* per ton; medium plates, ¼ in. and thicker, rolled in sheet mills, 21*l.* 15*s.* per ton; black steel sheets, No. 24 gauge, 22*l.* 15*s.* per ton; and galvanised corrugated sheets, No. 24 gauge, 26*l.* 2*s.* 6*d.* per ton, all for home delivery.

*Malleable-Iron Trade.*—Conditions in the malleable-iron trade of the West of Scotland have been fairly good during the past week and reports show that a good deal of buying has taken place, with the result that most makers are fully employed. Stocks of scrap are still light. It is understood that the Control Order No. 15 will not be brought into operation until the beginning of October, as certain details have still to be worked out. The re-rollers of steel bars report no change in the state of trade and although they still have good orders booked they could undertake more work for early delivery. The stocks of semies are ample to meet all requirements for a considerable time. The following are the current quotations:—Crown bars, 15*l.* 12*s.* 6*d.* per ton; No. 3 bars, 13*l.* 12*s.* 6*d.* per ton; No. 4 bars, 13*l.* 17*s.* 6*d.* per ton; and re-rolled steel bars, 17*l.* 15*s.* per ton, all for home delivery.

*Scottish Pig-Iron Trade.*—The demand for Scottish pig-iron is still heavy and all the furnaces in blast are operating at maximum capacity. The steelmakers' consumption of hematite particularly is extremely heavy. While users of foundry iron are not exceptionally busy, there is a good deal of business booked and the demand for foundry grades has improved. Stocks of iron ore are satisfactory. To-day's market quotations are as follows:—Hematite, 6*l.* 18*s.* 6*d.* per ton, and basic iron 6*l.* 0*s.* 6*d.* per ton, both delivered at the steel works; foundry iron, No. 1, 6*l.* 5*s.* 6*d.*, per ton, and No. 3, 6*l.* 3*s.* per ton, both on trucks at makers' yards.

OLD CENTRALIANS.—The June issue of *The Central*, the journal of the old students of the City and Guilds Engineering College, Exhibition-road, South Kensington, London, S.W.7, and of its predecessors, has recently come to hand. In addition to the usual "College" and "Old Student Notes," the issue contains interesting articles on "The Civil Engineering Contractor and the War," by Mr. H. J. B. Harding; "The Channel Tunnel," by Mr. Rolt Hammond; and "The Cauvery-Mettur Project in Madras," by Sir A. Chatterton, C.I.E. An obituary notice, and portrait, of Emeritus Professor Miles Walker, F.R.S., and a number of book reviews are also included. The price of the issue is 2*s.* 6*d.*

# FLUORESCENT TUBULAR LAMP.

MESSRS. THE EDISON SWAN ELECTRIC COMPANY, LIMITED, LONDON.

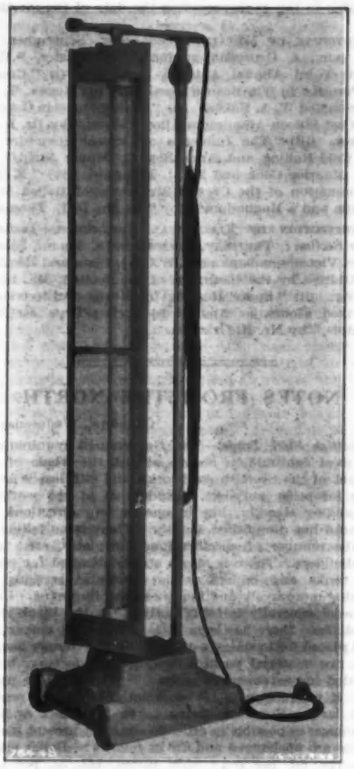

FIG. 1. PORTABLE LAMP UNIT.

FIG. 2. LAMP INSTALLATION IN FACTORY.

## THE EDISWAN FLUORESCENT TUBULAR LAMP.

LAMPS based on the passage of a current through a gas or vapour contained in a closed vessel have shown remarkable development since the introduction of the mercury-vapour lamp by Cooper-Hewitt some 30 years ago. The chief disability of the mercury-vapour lamp is the absence of red rays from its spectrum, so that the colour makes it unsuitable for general application, although it is still employed for special purposes. A definite improvement in the colour of the light was obtained by the introduction of the high-pressure mercury discharge lamp, in which there is a background of continuous radiation. The later development employing fluorescence has given still greater colour improvement, and lamps of this class can now be made which give a very fair approximation to daylight.

The 80-watt lamp of this latter type, which is manufactured by Messrs. The Edison Swan Electric Company, Limited, 155, Charing Cross-road, London, W.C.2, consists of a tube 5 ft. long with an electrode of the type illustrated in Fig. 3 at each end. These consist of coiled filaments coated with electron-emitting oxide. The fins, to be seen in the figure, are for the purpose of reducing the voltage drop when an electrode is acting as an anode. The tube contains a small amount of mercury and is coated on the inside with a fluorescent powder. When the lamp is in use, the ultra-violet rays produced by the mercury-vapour discharge between the electrodes at each end, act on the fluorescent powder which produces the white light. As the powder is slightly phosphorescent, it radiates light continuously, so that although the mercury arc is extinguished every time the current cycle passes through zero, stroboscopic examination of the light shows it to be more continuous than that given by some other types of discharge lamp. The lamp lights almost immediately it is switched on, but as to obtain the full output it is necessary for the whole of the mercury charge to be vaporised, the output is some 20 per cent. below normal for about three minutes. After this it rises to about 10 per cent. above normal, gradually falling during the next quarter of an hour to a steady value of 2,800 lumens. The rise is due to a temporary increase in temperature before the establishment of steady conditions between heat generation and radiation. The lamp operates most efficiently with an ambient temperature of about 45 deg. F., but small variations from this figure do not affect the light output to an important extent. The lamps are designed for specific voltages between 190 and 260 on 50-cycle circuits, but small voltage variations have little effect.

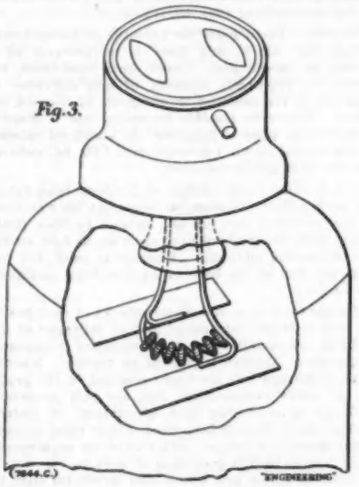

Fig. 3.

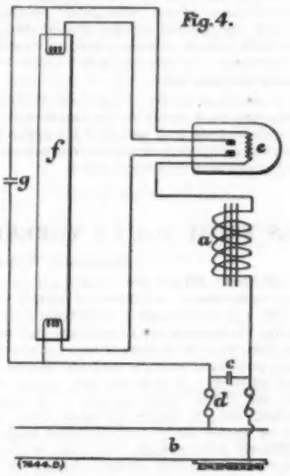

Fig. 4.

As to start the lamp it is necessary to heat the electrode filaments, these are connected to bayonet caps, as shown in Fig. 3, and there are two leads to each end of the lamp *f*, as indicated in Fig. 4. This diagram shows a choke coil *a*, which is introduced to enable the supply pressure to be adjusted to suit the lamp. As the choke introduces reactance, a condenser *c* is connected across the incoming cables from the mains *b*. As a rule the use of an 8 $\mu$F. condenser will give a power factor of 0·85 to 0·9. The circuit contains a thermal switch *e*, to which reference is made below, and it will be seen that when the two-pole switch *d* is closed, the contacts of the thermal switch being also in the closed position, the electrode filaments will be connected in series across the mains and are consequently heated. In this condition the full supply voltage is connected across the electrodes. This, however, is insufficient to start the discharge.

The thermal switch *e* is of the bi-metallic type and contains a heating coil which is in the main circuit when the lamp is switched on. The electrode filaments heat up rapidly and as soon as they have risen to the operating temperature, the coil of the thermal switch, which has also heated up, operates the bi-metallic strips and causes the contacts to separate. As these are on an inductive circuit, this causes a voltage surge across the electrodes which is sufficient to start the mercury-arc discharge between them and the lamp lights up, the current through the electrode filaments being broken, and remaining so as long as the lamp is in operation. The discharge through the lamp is sufficient to maintain the filaments at the necessary operating temperature. The purpose of the condenser *g* is to suppress any radio interference which the lamp might cause. Current continues to pass through the coil of the thermal switch while the lamp is in operation and retains the bi-metallic contacts in an open position.

In view of its shape the lamp is most conveniently employed in conjunction with a trough-shaped reflector. The control equipment may be mounted on a switchboard away from the lamp, but usually the most convenient arrangement is to incorporate it in the reflector fitting; only two circuit wires are then required. For local lighting, a portable unit mounted on wheels has been developed. This is illustrated in Fig. 1. The reflector can be swung through an angle of 270 deg. and the lamp may be used in either a horizontal or vertical position. The control equipment is housed in the base.

In mounting these lamps for workshop illumination regard must be had to the light distribution given by the elongated reflector. Symmetrical lighting can, however, be obtained without difficulty by placing the lamps at a suitable height and at suitable distances apart. As an example, an illumination of 20 foot candles can be obtained over an extensive area by mounting the lamps 7 ft. 3 in. apart and at a height of 5 ft. above the working plane. A single row of lamps at 6 ft. centres and 4 ft. above the working plane will give an average illumination of 35 foot-candles over a work bench 2 ft. 6 in. wide. As already mentioned, by suitably choosing the fluorescent medium these lamps can be arranged to provide a very fair approximation to daylight. An interesting illustration of the application of this characteristic is furnished by a recent installation carried out by the Edison Swan Company for Messrs. W. A. Smith and Company, Limited. This firm manufactures overalls made of a dark material which is trying to deal with in normal artificial light, and they state that since the installation of fluorescent tube lamps there has been a noticeable rise in output. The main works bay, a view of which is given in Fig. 2, has been equipped with 127 lamps, spaced approximately 8 ft. apart and at a height of 10 ft. from the floor.

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**Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The Proprietors will not hold themselves responsible for blocks left in their possession for more than two years.**

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## TEMPORARY ADDRESS.

**For the duration of hostilities, the Editorial and Publishing business of this Journal is being conducted from 18 and 20, Compton Road, Hayes, Middlesex. The Telephone Number of the Editorial Department is Hayes 1730, and that of the Publishing Department, Hayes 1723. The Bedford Street Offices are open on Fridays only, between 10 a.m. and 5 p.m., for the distribution of the current issue and for retail sales.**


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# ENGINEERING

*FRIDAY, SEPTEMBER* 12, 1941.

VOL. 152. No. 3948.


## RESEARCH IN ELECTRICAL ENGINEERING.

THE publication of the Electrical Research Association's report on "Surge Phenomena," a review of which will be found elsewhere in this issue of ENGINEERING, is a timely reminder of the national significance of electrical engineering research. It lends new emphasis to the fact that modern electrical engineering has only become possible by the application of the store of scientific knowledge which has been accumulated by many generations of research workers throughout the world and which, in general, has been the outcome of investigations that were originally undertaken without any thought of commercial application, but simply arose from the impulse to search for truth. About 25 years ago, industrial undertakings largely assumed that the responsibility for research rested with the universities, particularly as regards the basic sciences of physics and chemistry. Nowadays, however, while fully recognising the importance of research carried out by these institutions, industry in all parts of the world is shouldering responsibility even for fundamental research, because it realises that there are many advantages in concentrating its own efforts on the particular type of problems with which it is most concerned. This policy soon revealed to industrialists the fact that men who had qualified in the fundamental sciences of physics, chemistry and mathematics were particularly suitable for such purposes. They were more able to comprehend the nature of the industrial processes and frequently gave valuable suggestions for improving and developing them.

Many industrial undertakings now possess laboratories which are so well equipped and comprise such competent staffs that their research is of the highest quality and the question has been raised, on more than one occasion, whether the necessity for research work by the universities has not in this way become eliminated. The question, however, is ill-informed, and for several reasons. The demand for scientifically trained men in these industrial laboratories is already great and is rapidly increasing and it is essential that research work of a high order shall be in continuous progress in the universities in order that such men shall be properly trained. Quite apart from this aspect, experience during recent years has shown that an immense amount of pioneer work which has been rapidly applied to industrial processes has been done in this way and the claim of the universities to be leaders of scientific progress can hardly now be disputed.

For all practical purposes, the electrical industry began about 60 years ago, and its rapid growth was largely determined by the scientific knowledge which had been acquired since the foundations were laid by Maxwell and others for the scientific interpretation of Faraday's discovery of electromagnetic induction. Initiated by the invention of the electric glow-lamp of Edison and Swan, the need for the generation and distribution of electric power rapidly became urgent and this development formed the nucleus of the new electrical industry. With ever increasing competition, the industry has rapidly advanced and the past 25 years have surpassed all others in the progress which has been achieved. The post-war battle for foreign markets may be expected to be acute to a degree never yet experienced and, eventually, it will not be salesmanship or propaganda of other kinds—vitally necessary as these may be—which will give a country the lead in the electrical engineering export trade; it will be the unsurpassed quality, efficiency, and suitability of the product, combined with low cost. These essentials can only be ensured by means of persistent, comprehensive, and bold research, associated with scientific industrial development. The past few decades have seen whole industries wiped out as the result of technical advances, and many responsible executives have not yet fully realised this danger and adjusted their business to meet it.

Not long ago, public reference was made to an inquiry instituted by the investment departments of a number of large insurance companies who wished to determine, from an actuarial standpoint, the mortality rate of certain kinds of industrial undertakings. The report showed unanimous and emphatic agreement that the companies which succumbed had done little or no research work. These companies had simply continued to make old products and were overwhelmed by competitors who had adopted new methods and new machinery to manufacture products having more suitable properties for the purposes in view. It may be observed that new business does not depend merely upon the replacement of worn-out equipment or of consumed commodities, otherwise progress would practically cease our, standards of living would become stationary or decline, and unemployment would increase. It is the actual and purposeful creation of obsolescence by the development of new and improved products which determine the growth of business.

In a recent report on research in the United States, it has been shown that those industries which have made the most spectacular advances during the past 25 years have also been foremost in research. American industrial laboratories employ some 25,000 research workers and spend 20,000,000*l.* annually in research to develop new methods, to devise new machinery, and to manufacture new materials. Some industries appropriate from 2 per cent. to 4 per cent. of their gross income for this purpose, because they recognise that research is an essential part of any undertaking interested in efficiency and with long views which link the present to the future. Bankers, too, now admit that the research programme of an industry is a safeguard to the investment value of their securities. About one-quarter of the incomes of twenty leading universities in the United States is stated to be spent on research; six of them spend annually more than 400,000*l.* each on research. It will not be forgotten in this connection that the Cyclotron was invented and developed by Professor E. C. Lawrence in the University of California. During the period 1936-7, the United States Government spent more than 25,000,000*l.* on research. Even this amount is only about 4*s.* per head of the population.

In the light of these figures, it is disturbing to contemplate the pitifully meagre allotments which are made for research in this country. It would be unworthy of the land which produced Faraday, Maxwell, Kelvin, and J. J. Thomson, if, through a

failure to realise the responsibilities of our great inheritance, we were compelled to become followers instead of leaders of the world in electrical engineering enterprise. It has happened more than once that a pioneer discovery or invention of the first importance has been made in this country, but its scientific development and commercial exploitation have been left to other countries whose far-sighted industrialists were prepared to take the risks involved. A striking example of this is the development of the steel-tank mercury-arc rectifier. The practical realisation of this device presented formidable difficulties which at one time appeared to be unsurmountable, and it was due in the first place to the tenacity, technical skill, and financial support of one Continental firm that the task was brought to a triumphant conclusion. Further developments by this and other foreign firms have shown that the mercury-arc rectifier is likely to prove one of the most epoch-making developments since the discovery of the principle of the rotating magnetic field. It is no exaggeration to say that millions of pounds have been spent upon this work, and the results have shown the investment to be a veritable gold-mine; yet the principles involved were discovered by an Englishman, P. Cooper-Hewitt, about the year 1903.

Research controls the whole trend of progress in employment, agriculture, industry, and national defence, and its scope is unlimited. The dream of Edison and of Ferranti to produce an electric storage battery of very much less weight, less cost, and immensely higher efficiency than those already known remains a dream. Edison brought all his matchless resources to bear on the problem, and failed; yet, as a by-product of his investigations, the alkali battery emerged and results have shown that the financial returns on this by-product have repaid many times over the work and money expended on the original problem. The problem still remains one of the most attractive possibilities of the future. Suppose, for example, that a product of electricity were to be discovered which, weight for weight, had about the same energy content as oil, and that this energy could be reconverted into electricity as easily as the chemical energy in a lead battery. The consequent results would be revolutionary. Motor cars, aeroplanes, steamships, Diesel-electric trains, and all transport systems which now use reciprocating machinery in one form or another, could be driven by electricity.

It should not be assumed that, because Edison failed in this quest, the problem is insoluble. It may quite well turn out that the solution depends upon the stage of development which has been reached in other fields of research, such as the properties of materials, or upon new scientific facts which have been discovered in more recent years. For example, in 1880, Fritts filed a patent application dealing with talking motion pictures and an examination of this specification shows that it contains practically all the fundamental features which exist in the talking picture apparatus of to-day. The commercial development was delayed for a generation because the essential components could not then be produced; to mention one feature only, the photo-sensitive device used by Fritts would not respond to the frequencies of speech and music.

Probably the only organisation in this country concerning itself with electrical research which can stand comparison with corresponding foreign organisations is the engineering department of the Post Office, the Engineer-in-Chief of which controls a staff of about 30,000 and plant of the value of about 130,000,000*l.*, and it is the research carried out by this department and its associated organisations which has placed Great Britain in the front rank of achievement in telecommunication. The only purely research body for electrical engineering in this country is the British Electrical and Allied Industries Research Association, and this depends upon voluntary contributions from members of the British Electrical and Allied Manufacturers Association and from the Institution of Electrical Engineers. The amount of financial support which can be obtained in this way, however, for a basic industry of such importance as that of electrical engineering, is a national reproach for a country which depends for its existence on export trade.

## COLONIAL RAILWAYS.

THOSE who are attempting to proselytise in favour of some type of federal union between various countries, as a method of securing a more stable general world situation after the war, are faced with the problem of how to deal with the various colonies and dependencies. One proposal which has been advanced is for the setting up of some type of international colonial commission which would either administer the colonies, or supervise their administration by the countries to which they now appertain. What the future will bring we will not attempt to say, although it is possible that the relation between some colonies and their mother countries may be modified. This happened after the war of 1914-1918, and, as an example, Tanganyika Territory, a former German colony, was placed under a British mandate, and has so remained to this day. While refraining from speculation, we suggest that it is not likely to return to its former owners after the end of the present struggle. The drawing-up of a future world constitution may usefully be left until we are a little nearer the end of the present rough road. Even if changes are postulated, they will take a long period to come into effective being, and for many years our duty will remain, as now, to administer the colonies as to foster their material and cultural progress. Their standing in any world constitution will depend, as it has in the past, on the faithful performance of our responsibility.

Economically, the main function of the colonies in the structure of world trade is to provide raw materials, of which sugar, tea, rubber, tin and coffee are important examples. The demand for these and some other commodities, and the prices they realise, determine the financial standing of the countries concerned, which have not the alternative sources of income which may be present in more industrialised states. It is probable that some of the colonies are experiencing financial embarrassment at the present time owing to the complete cessation of many branches of world trade. In 1938, Germany, France and Italy took 10 per cent. of the domestic exports of Nigeria, the Gold Coast Colony, Kenya and Uganda, Tanganyika, and Ceylon. This trade will have ceased entirely, and although it will be compensated for to some extent by war demands from this country and the United States, this in turn is conditioned by the world shipping shortage. Present conditions, however, involve too many unknowns to be discussed in concrete terms. The past furnishes a better guide to an understanding of the position the colonies occupy in world trade. An illuminating review of that past, over the ten years preceding the outbreak of the war, is given by Mr. J. W. Spiller, C.M.G., M.Inst.C.E., in a recent paper presented to the Institution of Civil Engineers and entitled "Colonial Railways, 1929-1938: An Economic Review."

In explanation of the fortunes of the colonial railways, Mr. Spiller related them to the trade statistics of the world. Briefly, the position is that after a short boom, which followed the war of 1914-1918, there was a collapse in 1921. This was followed by a period of currency devaluation in many countries, but even during this difficult time world trade continued to increase, reaching a maximum in 1939. There was a growing demand for raw materials during this era, due to a considerable extent to the development of new industries. The relative figures for the world production of rubber, for instance, were 86 in 1921 and 254 in 1929, the figure for 1920 being taken as 100. The fall to 86 in 1921 was the immediate result of the trade collapse of that year. Between 1929 and 1938, the period covered by Mr. Spiller's review, there was a complete trade cycle, from prosperity, through a trade slump which reached its lowest point in 1932, back to a position in 1937 nearly as good as that of 1929. This was followed in 1938 by a new falling off in trade, but the curve was interrupted by the war and it is impossible now to say if a second world financial crisis was being approached.

The fortunes of the colonies followed the variations in value of world trade, and a curve plotting the foreign trade of, for instance, the Gold Coast between 1929 and 1938, follows the curve of world trade in a remarkable way. A curve of railway receipts, however, shows a quicker recovery, and the curve of revenue of the Gold Coast railway began to climb in 1932 at a much quicker rate than world-trade values. Comparable results were shown by the railways of Nigeria, Kenya and Uganda and Tanganyika. Conditions in Ceylon and the Federated Malay States were less satisfactory. One of the main causes of the slump of 1932 was certainly the fall in wholesale prices and, as railway earnings are dependent more on volumes than values, it was natural that the railway curves should be somewhat better than that of world-trade values. Low prices may result in reduced railway charges in order to conform with the financial possibilities of the traffic and railway revenues will certainly suffer from the reduced wealth of a country, following wholesale-price falls and consequent reduction in imports. On the whole, however, railway receipts will hardly tend to fall as seriously as world-trade values. Ceylon and the Federated Malay States form somewhat special cases. The chief exports of the former are copra, rubber and tea and in each case the volume exported was less in 1938 than in 1929. The railways also suffer to an unusual extent from road competition, the hauls being comparatively short and the roads good. The Federated Malay States railways have suffered from the ill-advised Stevenson scheme which, in 1922, a time of falling prices, restricted the growing of rubber in British territory, but exercising no control over Dutch planters. The final result has been that, while in 1929 the ratio of Malayan to Netherlands East Indies rubber production was 1·75 to 1, in 1935, it had fallen to 1·48 to 1; and in 1939 the basis tonnages of the two territories was practically identical. The scheme was abandoned in 1928.

The war of 1914-1918 was followed by extensive railway construction in the Colonies, the total mileage built between 1919 and 1929 aggregating 2,100. Since 1929 only a few miles have been brought into use and for many years now new construction has ceased. In a country as highly developed as England, it is natural that railway construction should show signs of nearing a static condition, but in none of the Colonies is it possible to contend that the railway network adequately serves the whole country. Indeed, the word network is inapplicable, the railway system frequently consisting only of a few spur lines from the coast. The Gold Coast Colony, embracing Ashanti and the Northern Territories, extends some 440 miles inland, but the main railway covers only about a third of the distance. In all the Colonies of this African coast, from French Senegal in the east to Nigeria in the west, the railways are carried much farther into the interior than they are in the Gold Coast, and yet the latter is probably the richest of them all. It grows more cocoa than any other country in the world and mines about 10 per cent. of the world production of manganese ores. The excellent deep-water harbour at Takoradi could handle greatly increased exports. Surveys have been made for extensions in the Northern Territories by both east and west routes.

Mr. Spiller, who quotes this example, and others from other Colonies, suggests that the absence of new railway construction in recent years may lead to an idea that further extension of the Colonial railways is unnecessary. This is far from being the case. Wide territories of great potentiality are waiting to be opened up, and in a world in which industry every day becomes more extended and complex there is a growing demand for colonial products. The situation cannot be met by the construction and improvement of roads. The prosperity of the colonies depends to a large extent on bulk materials, which in all countries, even those with the most developed highways, are carried by rail. In some cases assistance in the form, for instance, of cheap loans might be necessary for railway extensions, but in general the existing railways are approximately paying their way, and new lines would not be likely to form a serious charge on public funds. Even if the lines could not show a commercial profit, their value in the further development of the colonies would be their justification. It is the clear duty of this country to foster their development in every possible way.

# NOTES.

### THE PROGRESS OF THE WAR.

THE Prime Minister's review of the war position, delivered in the House of Commons on Tuesday, September 9, did not exaggerate the effect of the force of the Allied arms or minimise the dangers with which Britain, in particular, is still confronted; but, nevertheless, there was a sober optimism in its tone which was the more convincing, in its studied moderation, than more florid oratory could have been. His account of his meeting with President Roosevelt, and the clear delimitation of the scope of the "Atlantic Charter," added little to the official statements already made, but provided a useful corrective to those who would interpret the "Eight Points" as definitive to an extent that it was never intended to be and, in the present state of affairs, could not be. Mr. Churchill's remarks on the shipping position, taken in conjunction with the most recent statistics of British losses and the figures relating to Allied shipping, which are published elsewhere in this issue, are encouraging; even though, as he emphasised, the "Battle of the Atlantic" still continues unceasingly. Some sinkings must be accepted as inevitable, when it is remembered that Britain has never less than 2,000 ships at sea, and 400 of them in the danger zone. He drew particular attention to the work of the submarines and of the Royal Air Force in swelling the enemy's shipping losses, and of the minesweeping and salvage services in reducing those of the Allies, adding that more than 1,000,000 tons of ships had been salved since the beginning of the war. Some indication was given, also, of the continuing magnitude of the military supply problem in his allusion to the armies in the Middle East, "which begin to approach 750,000" and "are being supplied with masses of equipment of all kinds." As he observed in conclusion, the tale of achievements, shorn of intimate details though it was, should "earn the respect of history, whatever the future may contain."

### THE WELDING RESEARCH COUNCIL.

The fourth report of the Welding Research Council, which has been issued in conjunction with the 18th annual report of the Council of the Institute of Welding, shows that the work of the Research Council has proceeded actively in spite of war-time difficulties. The research income from industrial contributions for the year ended March 31, 1941, was 5,007*l.*, representing an increase of 704*l.* over that for the previous year. This satisfactory result is due mainly to the special appeal which was launched in order to obtain the maximum benefit from the agreement made with the Department of Scientific and Industrial Research, and has enabled a grant of 2,820*l.* to be claimed from the Department. Investments for reserve have been increased by 2,000*l.*, making a total of 4,924*l.*, and further funds are to be added to this figure as they become available, to provide the necessary means to undertake full-scale research operations on the conclusion of the war. As in previous years, much of the research work has been carried out by users of welding processes, by makers of welding apparatus, and by the metal-producing industries, without charge to the research funds of the Institute; but pressure of other work has restricted this collaboration latterly, and, to enable certain urgent problems to be investigated, Mr. R. F. Tylecote, M.A., M.Sc., and Mr. J. G. Ball, B.Sc., have been appointed as research assistants. Summaries of the work of the various committees appointed by the Research Council, appended to the main report, indicate the considerable volume of research that is in hand or has been recently completed. The Committee on Weldability of Ferrous Metals have concluded their investigation of eleven low-alloy high-tensile steels, finding that the weldability of steel is inversely proportional to the quantity of alloying elements contained in it, the predominating element being carbon. A report on high-alloy high-tensile steels has been published also, and other reports are either ready for publication or are in an advanced state. The corresponding committee on Non-Ferrous Metals have been investigating the fluxing problems involved in gas-welding aluminium and its alloys, and expect to produce shortly a report on the influence of impurities and additions on the welding behaviour of deoxidised copper. Fluxing action in the welding of other non-ferrous materials is also to be examined. The committee on Weld Shrinkage and Internal Stress are analysing the experimental data on residual strains and stresses in arc-welded plates, and have submitted a preliminary report on testing the hot cracking tendencies of welds deposited from mild-steel electrodes. The programme of the committee on Welded Construction has been interrupted by the war, but an interim report, on small-scale plate girders with unstiffened webs, has been submitted to the sub-committee dealing with plate-girder bridges. The testing equipment for the research on the load-carrying capacity of rigid frameworks has been transferred from Bristol to Leeds University, where this work has been resumed. The committee on Resistance Welding have also been hampered by circumstances, but have made some progress and are examining into the strength of spot welds in mild-steel plate from $\frac{1}{4}$ in. to $\frac{3}{8}$ in. thick, and the effect of cold work on the fatigue value of spot welds. The committee on Welded Pressure Vessels have prepared a memorandum on the welding of pressure vessels and are continuing their research on the weldability of steels for pressure equipment and pressure pipe-lines. The Welding Industry Committee of the British Standards Institution have been active in revising old standards and preparing new, their subjects including steel structures welded by metal arc and by oxy-acetylene, tubular steel structures, the welding of copper, crane structures, standardisation of blowpipes, rating of arc-welding plant, etc.

### MOBILE ENGINEERING SQUADS.

A development possessing features of some novelty has been initiated by the Ministry of Supply as a means of accelerating production and reducing the "shake-down" period in the new munition factories now coming into service in different parts of the country. The shortage of skilled labour, now being increasingly felt, tends to retard the normal processes of bringing such new establishments up to their designed rate of output, and to provide some additional initial impetus, mobile squads of about 50 highly skilled craftsmen have been formed, which can be sent at short notice to any part of the country. The squads are made up of fitters, drillers, turners, tool setters, etc., as circumstances may require, and are drawn from the personnel of established ordnance factories. The men are all volunteers for this duty, and are usually sent to the desired centre for a period of about a month. Their purpose achieved in one part of the country, they may then return to their original employment or be sent to some other new factory, as may be necessary. By their readiness to undertake this arduous duty, it is stated, a most valuable national service is being performed in giving a flying start to production in the new factories.

### THE BRITISH ASSOCIATION.

Although the ordinary summer activities of the British Association are suspended for the duration of the war, arrangements are being made this year to hold a special conference of a sectional, but international, character under the auspices of the Association's Division for Social and International Relations of Science. The conference will occupy three days, September 26, 27 and 28, and the meetings are to be held at the Royal Institution, Albemarle-street, W.1. The general aim is "to demonstrate the common purpose of men of science in ensuring a post-war order in which the maximum benefits of science will be secured for all people," and its international character will be emphasised by the collaboration of diplomatic and other representatives of the British Empire, China, Czechoslovakia, Russia, and the United States. At various sessions, the chair is to be taken by Mr. John G. Winant, the United States Ambassador; M. Maisky, the Russian Ambassador; Dr. Wellington Koo, the Chinese Ambassador; Dr. Benes (President of Czechoslovakia); Mr. H. G. Wells; and Sir Richard Gregory (President of the British Association). Poland, Holland, Norway, Free France and Belgium will also be represented.

# SOME ASPECTS OF THE WAR AT SEA.

By ADMIRAL SIR HERBERT RICHMOND, K.C.B.

(*Concluded from page* 195.)

THE effect of the fall of France went farther than bringing in Italy; it exposed Britain to the danger that France also might be added to our enemies. Whether the destruction of the French ships at Oran was a politic act must be reserved for decision when all the facts are known. France had been released from the self-invited obligation not to make a separate peace, on the definite condition that, before negotiations were begun, the French fleet should be sent to British harbours. In spite of this, and of "every kind of private and personal assurance" from Admiral Darlan (to quote the Prime Minister) that the fleet would not be allowed to fall into German hands, the armistice was made without transfer of the fleet, and provided for its demobilisation in ports under German control. The sole safeguard that it would not be used against us was the totally valueless word of Hitler and his generals. It was natural, therefore, that the British Government should consider the step of destroying it. Comparison has been made between the attack at Oran and the capture of the Danish fleet in 1807 to prevent it from falling into the hands of Napoleon. There is, however, a marked difference between the two events. The Danish fleet which was taken into preventive custody was the whole Navy of Denmark. The fleet at Oran was a portion only of the French Navy—four ships of the line, a few cruisers and destroyers, and some submarines. The bulk of the surface flotilla and submarines were elsewhere; and they are craft which, as we have seen, play a considerable part in this war. It is at least open to question whether the sinking of three capital ships (for one of them, the battleship Strasbourg, escaped), with the loss of 2,000 men, was not dearly bought at the cost of arousing the intense hatred of the French Navy.

In the light of the antagonism that followed, the possibility that Dakar might be placed at the disposal of the enemy could not be ignored. The port flanks the Atlantic routes which were carrying, in addition to their own trade, the trade previously passing through the Mediterranean from the East. It was obvious, therefore, that it was desirable in the highest degree that the control of Dakar should not pass into hostile hands. An expedition, composed partly of Free French and partly of British forces, was therefore prepared to take possession of the port, the population of which was said to be unfavourably inclined towards the Vichy regime.

One outstanding lesson of long experience of expeditions sent to aid disaffected communities against existing rulers is that no dependence should be placed upon receiving local support; the forces sent should be sufficient to carry the operation through by themselves, independently of either active or passive co-operation from within the place. Further, it is hardly less elementary to recognise that expectations of passive behaviour or active help may be disappointed, and therefore it should be clearly decided before the expedition starts whether, if local opposition is encountered, it is to be overcome by force. Finally, every precaution should be taken not only to conceal the movement, but also to ensure that no reinforcements reach the garrison, and that the necessary orders should be given and dispositions made to ensure that officers know how to act and have the forces necessary for action.

In the Dakar affair, all these points appear to have been neglected. General de Gaulle's optimistic belief that he would be welcomed by the inhabitants seems to have been accepted without question. The possibility that his judgment might be mistaken should assuredly have been recognised and the decision made beforehand whether force should be used, even though it would mean setting Frenchmen against Frenchmen and Britons against their former allies. No clear orders appear to have been given to the naval commander at Gibraltar to intercept and turn back any French forces seeking to go to Dakar, nor was the squadron at Gibraltar

strengthened to a point which should ensure that its request could be accepted by a French commander without loss of honour. In consequence of these strange lapses, Dakar was a distressing fiasco. The expedition came, saw and went away, British prestige received a severe blow, and the way was left open for German penetration at this vital spot on the trade routes.

The war on the trade routes began, as previously stated, with submarine attacks in the western approaches and surface attacks on the ocean. Though the losses were heavy in the first month, the Admiralty were able to report "excellent progress" in countering the submarine attacks at the end of the month. When the convoys were in working order the losses of ships in convoy fell to a low figure; but all shipping did not sail in convoy. Still, up to the time of the fall of France it could be said that the situation was being got in hand. After May, 1940, however, the sinkings became alarming; in June, they exceeded half a million tons. Besides losing the support of the French Navy, we had the new German submarine construction coming into use and also the motor torpedo boats; the submarines developed new tactics of working in company, shadowing convoys by day and penetrating into the heart of them after dark; and the widespread use of mines caused great damage—particularly the magnetic mine, until its antidote was discovered. With the French and Low-Country ports in his hands, the enemy could now use aircraft not only in the North Sea but also in the Channel and Atlantic, and their co-operation with submarines, by giving them information of the whereabouts of shipping, was an advantage to those craft. The need arose to arm the ocean-going merchant ships against air attack with bombs, and to give their wheelhouses protection against machine-gun fire with armour-piercing bullets, and it was no easy matter to produce the necessary guns and to fit a suitable type of armour. Finally, there was the addition of the Italian submarines, which, though their menace was not very serious, took some share in the Atlantic Battle.

The expansion of the anti-submarine and anti-aircraft forces was necessarily slower than the growth of the threat from those causes. This is a fact which should be fully realised throughout the Empire. It impresses the need for the existence, at all times, of an ample flotilla force, maintained by all the members of the Commonwealth. The example of the Confederacies of Delos might well be considered by all of us of the modern maritime State. By the terms of that agreement, every State of the Confederacy, however small, had the duty of making some contribution to the common fleet. Many of the States were poor and could not furnish more than one or two vessels; others could do no more than contribute a part of the cost of a single galley; but, large or small, all made contributions proportional to their capacities. The growth in the importance of the flotilla, in modern war at sea, and our experience of the effects of being insufficiently provided until heavy losses have been sustained and the time lag of construction is overcome, render the development of a policy on these lines a matter deserving the most exhaustive examination.

The attack on trade by surface ships, though it has made its contribution to the pressure on our sea communications, has not produced the results that the enemy may be expected to have hoped from it. Its effects are not to be measured only in the tonnage sunk—the proportion of the total sinkings is apparently in the neighbourhood of 15 per cent.—but also in the diversion of fighting forces which it causes, taking them from other duties of a major strategic character, such as the military operations in the Mediterranean and the blockade. A French admiral, a little more than a century ago, went so far as to say that this diversionary effect was the more important of the two. The attack began, as previously mentioned, in September, 1939, with the dispatch of the Graf Spee on her Atlantic cruise, which was brought to an end in the River Plate on December 3. Why only one of the three armoured cruisers was sent out on the trade routes cannot be said. The decision stands in a marked contrast to the doctrine of the *Blitzkrieg*—the principle of throwing all possible forces into the campaign simultaneously, and swiftly crushing resistance. It may be that difficulties were found in the way of providing supplies, but this can only be conjecture. A second ship of the same type sallied out a little later and sank the Rawalpindi in November, evading, in the long dark nights of the northern latitudes, the forces which attempted to intercept her on the return voyage. For some time after this, little was heard of the two ships that remained. They took part in the Norwegian campaign, in which one was damaged by a torpedo, and one of them again appeared on the trade routes and attacked a convoy defended by the Jervis Bay on November 5, 1940. In December, a heavy cruiser, possibly the Hipper, attacked another convoy and was driven off by the escorting heavy British cruiser Berwick.

The armed merchantman, or auxiliary cruiser, plays a part in the oceanic areas. Both enemies have employed them, but in what number is not known. The activities of the Italians suffered when the British forces in East Africa captured all the Italian ports there and so deprived them of bases. The enemy has a certain advantage in this branch of warfare since, needing only to send out a comparatively small number, he can give them a more effective armament than we can, who have to fit out many more. Protection against this form of attack in the wide open spaces of the oceans is difficult, but the expanse does itself afford a measure of security. The enemy, if he is to make many captures, must operate in areas in which he can expect to find many targets. Seeking his prey in the open waters in which shipping can be scattered will produce some prizes, but nothing compared to what are to be got in the congested focal spots and passages through which all vessels have to pass. With a limited number of defending vessels, the ships can be protected in those parts either by being convoyed or by cruisers. If, as has been the experience sometimes in past wars, the enemy hunts in couples or even larger numbers, a strong escort is needed. A "regular" cruiser would be a match for even a concentration of these auxiliary vessels, but our numbers of these, as was pointed out previously, are unduly limited. The alternative is to increase the escort of auxiliary ships. Flying boats, as they become available, will probably prove useful. The armed vessel is as vulnerable as any other to the torpedo, and there are stretches of water in which a strong patrol of such boats can be maintained.

After the French ports became enemy bases the attack on trade was strengthened by battle cruisers, of which Germany possessed two. These were sent out in the spring of 1941 and made a cruise in the western Atlantic which did a great deal of damage to the ships not sailing in convoy, no less than 22 being sunk. By then the convoys had been strengthened in anticipation of this action and on one or more occasions it appears that, when they were approached by the battle cruisers, these beat a hasty retreat when they found that the convoys had the protection of battleships. Unfortunately, the speed of the battleships was not enough to enable them to bring the attackers to action. The culmination of this process of growth in the strength of the attack, which seems always to occur in convoy work, came with the dispatch of the new battleship Bismarck. This ship, laid down in 1936, was built under the terms of the agreement that battleships should be limited to a tonnage of 35,000. Reports appear to agree that she greatly exceeded that tonnage; if so, the argument that great tonnage is a necessity in order to prevent evasion falls to the ground. While one purpose of the Bismarck's cruise was trade attack, it seems improbable that so great and valuable a ship would be sent out for that purpose alone. One may easily discern other possible objects. Thus, counting on her great strength, and in the expectation that convoys would be protected by no more than one battleship (and that one possibly of the older type, and therefore no match for the modern ship), she may have hoped to intercept such a weaker force and destroy it. She may have been intended to finish her cruise at Brest and thence to operate in company with the Scharnhorst and Gneisenau and the two 10,000-ton cruisers Hipper and Prinz Eugen, either on the trade routes or in one part of an invasionary plan. Or again, her destination may have been Dakar, where, in company with the repaired Richelieu, the possibly completed Jean Bart, the Strasbourg and other French cruisers, a combined squadron of great strength would have threatened the South Atlantic route. Such a combination would be the more effective if Gibraltar were rendered untenable by British squadrons. Whatever may have been the intention of her sally, her destruction was a stroke of very great importance. It was the equivalent of a battle of fleets; for in the war to-day the strength which in earlier times was disposed among a number of ships is now concentrated in a few hulls.

What the future holds in the way of surface attack remains to be seen. The bombardments of the battle cruisers in Brest and at La Pallice have kept those two dangerous ships in port since the end of March; but they are not yet destroyed or disabled, other than temporarily. They remain to threaten as before, and to contain a portion of our heavy forces, for which we may have need in other parts of the world before the year is out.

Which is the most destructive of the five principal instruments used by the enemy against British shipping? Various estimates seem to have been made and the proportions probably vary from time to time. Up to the end of June, 1941, when the Admiralty ceased to issue returns of monthly losses, the world tonnage lost consisted of 1,737 ships of 7,125,696 tons; of this total, 1,076 ships of 4,608,460 tons were British. In terms of tonnage (which differ from the terms of numbers) the percentages of losses of British shipping appear to be approximately as follows: by submarines, 56 per cent.; by mines, 11 per cent.; by surface ships, 15 per cent.; by aircraft, 16 per cent.; and from other causes, 2 per cent. But the losses have not been all on one side. While Britain and the Allies have lost some 6 million tons, the enemy has lost, according to the Admiralty estimate issued on August 20, about 4 million; but whereas enemy shipping has ceased to ply except in the enclosed waters of the Baltic and furtively coastwise, British trade continues. The sea blockade cuts off practically all supplies to both of our principal enemies, and though there may be some leakage through certain channels, in part due to consideration for neutral needs, it seems safe to assert that the enemy Powers are isolated effectively since the back door through Russia was closed by Hitler's own action.

It is not yet possible to attempt the final answer to some of those questions that were the subject of much controversy before the war—whether, for example, the submarine, and aircraft, and flotilla types of fighting craft, have made the battleship obsolete; or whether the great sizes of to-day are intrinsically (as distinct from extrinsically) necessary. On these and other matters we must be prepared to admit errors in earlier opinions. But certain things are as clear as they can be: this maritime Empire, or, if the word is preferred, Commonwealth, must not again allow its sea forces to fall below the standard needed for security. The strength that we need must exist in peace; it cannot be suddenly created when war comes upon us in the swift forms that war takes to-day. The Merchant Navy must be fostered as it was fostered by our rulers in the past, from the days of the Plantagenets onwards; and we must ensure that there is unity of direction and control in every stratum of the strategy and tactics of the fighting forces, with complete liaison between the three Services as a whole and between their several arms.

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FIBRE SUBSTITUTE FOR BALING WIRE.—A fibre substitute for baling wire, known as Balax, is being made by Messrs. British Ropes, Limited, Anchor and Hope-lane, Charlton, London, S.E.7. The company, who are large manufacturers of baling wire, have introduced the material in order to conserve supplies of steel. It is being used by public authorities and industrial firms for baling waste paper. The production of Balax is now subject to the Hemp Control Section of the Ministry of Supply, Washington Hotel, City-road, Chester, and orders for the material must be accompanied by a form, copies of which are obtainable from the Hemp Control.

# OBITUARY.

## MR. W. L. MANSERGH.

It is with regret that we record the sudden death, on September 3 at Woking, Surrey, of Mr. Walter Leahy Mansergh, a partner in the firm of Messrs. James Mansergh and Sons, consulting engineers, 5, Victoria-street, London, S.W.1. He was a son of the late Mr. James Mansergh, F.R.S., a past-president of the Institution of Civil Engineers, and was born at Hampstead, London, on October 23, 1871. He was educated privately and after attending University College School from 1887-89, took the engineering course at University College, London, under Professor T. Hudson Beare. In August, 1891, he entered upon a pupilage of three years under his father, during which he was mainly engaged on Parliamentary surveys in Wales for Birmingham water schemes. In 1894, at the age of 23, he was appointed assistant in his father's office, and during the following years was employed on preparatory work and on reports in connection with waterworks for Birmingham (Elan Supply), Worthing, Keswick, Leigh, Rochford and Whitby. He was also engaged on similar tasks in connection with sewerage works at Coventry, Exmouth, Southend and Worthing. In addition he travelled abroad with his father during the latter's inspection of water-supply works at Toronto (1895); drainage works at Colombo (1896) and water-supply works at Buda-Pest (1898), and assisted in the collection of material for the preparation of Mr. James Mansergh's reports.

In 1899 Mr. W. L. Mansergh served as resident engineer, under Mr. G. N. Yourdi, on the Caban Coch Dam of the Birmingham Waterworks, and in the following year resumed his work as assistant in the Westminster office of Mr. James Mansergh. In January, 1902, he was taken into partnership by his father, and subsequently took an active part in the preparation of designs and in superintending the construction of works connected with water-supply schemes at Birmingham; the Tees Valley, at Stockton and Middlesbrough; Carlisle; Tynemouth; Lancaster and elsewhere, and with sewerage and sewage-disposal schemes at Bromborough, Plymouth and Derby. Mr. Mansergh, who became a student member of the Institution of Civil Engineers in 1891, was elected an associate member in 1897 and transferred to the class of member in 1908. He was also a member of the Association of Consulting Engineers.

## MR. W. MACNAB, C.B.E.

By the death of Mr. William Macnab, which occurred at Cookham Dene, Berkshire, on September 2, the British chemical engineering industry has sustained a notable loss. Mr. Macnab, who was an authority on explosives, was the son of the late Mr. William Macnab, shipbuilder and engineer, of Greenock, and was born in that town in 1858. He was educated at Greenock Academy and afterwards studied chemistry at the Edinburgh Institution and at the University of Glasgow. As a young man he took up the subject of sugar refining and, in 1878, went to Germany to establish a laboratory for the analysis of raw beet sugars at Magdeburg. Subsequently a process of water-softening engaged his attention and he visited the United States on behalf of the originators of the process. His long connection with the explosives industry began towards the end of last century when, in association with Mr. C. Napier Hake, he was engaged in the building and equipment of a factory for the production of Roburite, a smokeless and flameless explosive for use in mines. In 1909 Mr. Macnab served as honorary secretary of the seventh International Congress of Applied Chemistry. In the following year he was appointed a member of the jury at the Brussels Exhibition, and in 1911 he occupied a similar position in connection with the Turin Exhibition.

Soon after the outbreak of war in 1914, Mr. Macnab was made a member of Lord Moulton's Committee on Explosives, and, later, as technical adviser in the Department of Explosives Supply of the Ministry of Munitions, took a leading part in the construction and organisation of explosives factories built in various parts of the country. Subsequently he compiled the *Technical Records of Explosives Supply*, 1915-19; he also published, in collaboration with Mr. C. N. Hake, a translation of Berthelot's *Explosives and their Power*. For his work during the last war he was made a C.B.E. in 1920. He was elected a Fellow of the Institute of Chemistry in 1887 and, after serving on the Council for several terms, acted as vice-president from 1921 to 1924. He became a member of the Institution of Chemical Engineers in 1923 and was elected president in 1934. The William Macnab Medal of this Institution, it may be recalled, is awarded annually to the candidate submitting the best papers in the associate-membership examination. Mr. Macnab was also for many years a Fellow of the Chemical Society and a member of the Society of Chemical Industry.

# THE ALLIED FLEETS.

From time to time, vague indications have been given from official sources of the extent to which the naval and mercantile shipping of the Allies have been co-operating with those of Britain and the British Empire; but no definite figures have been disclosed. The Ministry of Information, however, has now released some official statistics which, though still incomplete, do present a more exact picture of the nature of this co-operation than it has been possible to visualise hitherto. The accompanying Table I shows the numbers and types of the majority of the ships, and the numbers of officers and men, serving the Allied cause under the flags of Free France, Norway, Holland, Poland, Greece, Jugoslavia, and Belgium. As mentioned, the statement is incomplete, as it is not practicable to disclose the number of submarines included in the total, nor any particulars of the vessels representing the navies of Greece and Jugoslavia; but the Greek personnel includes 140 officers and 1,600 men, and Jugoslavia adds another 20 officers and 200 men, so that, together, they form an appreciable percentage of the total. In all, there are 187 vessels in these forces (including those in the undisclosed categories), manned by 1,230 officers and 13,500 men.

TABLE I.—The Allied Navies.

| Class of Ship. | Free France. | Norway. | Holland. | Poland. | Belgium. | Totals. |
|---|---|---|---|---|---|---|
| Cruisers | — | — | 1 | — | — | 1 |
| Destroyers and torpedo boats | 3 | 6 | 4 | 6 | — | 19 |
| Gunboats, sloops and corvettes | 11 | 4 | 4 | — | — | 19 |
| Minesweepers, patrol and small convoy vessels | 3 | 37 | 24 | — | 6 | 70 |
| Smaller fighting vessels | 15 | 9 | 1 | 3 | — | 28 |
| Harbour service vessels | 10 | 2 | 5 | — | — | 17 |
| Totals | 42 | 58 | 39 | 9 | 6 | 154 |
| Personnel: Officers | 290 | 250 | 315 | 200 | 12 | 1,230 |
| Men | 4,100 | 2,500 | 3,000 | 1,350 | 200 | 13,500 |

The numbers and tonnage of the Allied mercantile fleets also provide some impressive totals. At July, 1941, the Allied ships in service numbered 1,617, of an aggregate tonnage, in round figures, of 7,250,000, the proportions being as follows:—Free France, 92 ships, of 400,000 tons (some of these are sailing under the British flag); Norway, 719 ships, of 3,250,000 tons; Holland, 480 ships, of 2,250,000 tons; Poland, 32 ships, of 100,000 tons; Greece, 240 ships, of 1,000,000 tons; and Belgium, 54 ships, of 200,000 tons. In addition, there have been a further 335 ships, totalling approximately 1,500,000 tons, which have been lost as a result of enemy action since the countries to which they originally belonged were overrun by Germany. Somewhat more detailed figures of these losses, with the dates from which they are reckoned, are given in Table II, on this page. These figures do not include the 19 ex-French and 22 ex-Danish vessels, amounting to 88,400 tons and 70,000 tons, respectively, which have been sunk while sailing under the British flag and which, accordingly, have been included in the periodical statements of British losses.

TABLE II.—*Losses of Allied Merchant Shipping from the Date shown to June 30, 1941.*

| Nationality. | Vessels of All Tonnages. | | Vessels of 500 Tons and Over. | |
|---|---|---|---|---|
| | No. | Gross Tons. | No. | Gross Tons. |
| Norwegian (9.4.1940) | 121 | 562,061 | 119 | 561,612 |
| Dutch (10.5.1940) | 77 | 371,714 | 64 | 367,617 |
| Belgian (10.5.1940) | 34 | 131,891 | 23 | 130,106 |
| Greek (28.10.1940) | 65 | 233,050 | 64 | 232,664 |
| French (3.9.1939 to 25.6.1940; and Free French from 25.6.1940, prior to transfer to British flag) | 34 | 174,667 | 28 | 173,611 |
| Polish (3.9.1939) | 4 | 29,210 | 4 | 29,210 |
| Totals | 335 | 1,502,393 | 302 | 1,494,820 |

# MOTOR-CAR ENGINE BEARING TEMPERATURES.

The Automobile Research Committee of the Institution of Automobile Engineers is engaged on an investigation covering the effect of bearing clearance, engine speed, lubricating-oil pressure, sump arrangement, and other factors, on the temperature of the main and big-end bearings of car engines. In view of the possibility that this research may have to be discontinued in favour of more urgent work, the Institution has issued two summary reports in order that the results so far obtained may be generally available.

The bench tests, which were conducted on a four-litre six-cylinder engine, were mainly concerned with the effect of diametral bearing clearance, jacket-water temperature and combustion heat. Temperatures of two main bearings and of two big-end bearings, of the oil in the bearing oilways and sump, and of the crankcase atmosphere, were measured by thermo-couples. The engine bearings were all of the thin-walled, steel-backed type, lined with white metal. The investigation covered bearing clearances ranging from about 0·0007 in. to 0·0055 in., over a speed range from 1,000 r.p.m. to 3,500 r.p.m. The highest speed of revolution represented a surface speed of 2,350 ft. per minute at the main bearings and 1,950 ft. per minute at the big ends. The tests were run at a b.m.e.p. of 30 lb. per square inch; previous tests had shown that the b.m.e.p. had little effect on bearing temperature provided that the oil-inlet temperature to the engine was kept constant. In the tests, this was 70 deg. C.

It was found that the effect of clearance on bearing temperature was very considerable. Main bearings having a clearance of 0·0007 in. showed a temperature of 152·5 deg. C. at a speed of 3,500 r.p.m., the figure for bearings with a clearance of 0·0055 in. being 84 deg. C. The corresponding temperatures for big-end bearings were 120 deg. and 80 deg. C. As the surface speed of the main bearings is greater than that of the big-end bearings, at any fixed engine speed, it might have been expected that the main bearings would show the greater temperature rise; the effect, however, is still found even when allowance is made for the difference in bearing diameter. At lower speeds, conditions are reversed and the main bearings show a lower temperature than the big-end bearings, the difference between the two, however, not being so great as at higher speeds. The report suggests that this effect may be due to the big-end bearings dissipating an appreciable proportion of their heat to the crankcase atmosphere at high speeds. The temperature of this atmosphere is always lower than that of the bearings. Bearings of all clearances showed a linear variation of temperature with speed.

In the experiments covering changes in the oil-inlet temperature, it was found that, at small clearances, the rise in temperature between the oil inlet to the engine and the bearing itself decreased as the oil-inlet temperature was raised, showing that the bearing temperature tends to be independent of the oil-inlet temperature. The results suggested that the use of oil cooling to reduce bearing temperatures is of little value for clearances less than about 0·0025 in. With large clearances, the bearing temperature tends to follow the oil-inlet temperature fairly closely. Increase of oil pressure from 40 lb. to 100 lb. per square inch caused a reduction in bearing temperature of about 50 deg. C. at all clearances and speeds. The effect of varying water-jacket temperature from 35 deg. to 95 deg. C. was found to have a negligible effect on

bearing temperatures at high speeds, in spite of the fact that the main-bearing housings and jackets were connected by substantial webs. At low speeds, an increase of 55 deg. C. in jacket temperature caused 10 deg. C. rise in bearing temperature.

This investigation confirmed the results of previous work which had shown the beneficial effect of light oils in reducing bearing temperatures. At 3,500 r.p.m., the substitution of an S.A.E. 20 for an S.A.E. 50 oil resulted in bearing-temperature reductions of 26 deg. C. for a main bearing with 0·0007 in. clearance, and 11 deg. C. for a big-end bearing with 0·002 in. clearance. The addition of 1 per cent. of methyl-dichlorstearate to the heavier oil, to improve film strength, had no effect on bearing temperature. In motoring tests, with the ignition switched off, and at constant oil temperature, the bearing temperatures recorded were little different from those found for power operation. This confirmed previous observations which had shown that high-power operation has only a secondary effect on bearing temperature by reason of the oil being heated after it has left the bearings. The general conclusions drawn from these bench tests are that bearing temperatures may be limited by avoiding very small clearances and, to a smaller extent, by control of oil temperature or crankcase atmosphere temperature. Oil pressure and jacket-water temperature effects are negligible, but the use of light oil is advantageous.

The most interesting result of the road tests, which were carried out on a 10-h.p. car with a four-cylinder engine of 63·5 mm. bore and 90 mm. stroke, was their bearing on sump design. The engine had three main bearings and all bearings were of the same type as those in the bench-test engine. The clearances were 0·0025 for the main bearings and from 0·001 to 0·002 for the big ends. Temperatures were measured by thermocouples, as before, but the accuracy attainable was not comparable with that achieved under test-bed conditions and changes of the order of 4 deg. C. were difficult to detect. The tests consisted of a series of runs at constant engine speeds ranging from 1,500 r.p.m. to 4,000 r.p.m., both in top gear and intermediate gears. Warming-up tests were also performed, the car being accelerated from rest to 53 m.p.h. (3,500 r.p.m.) as quickly as possible, this speed then being maintained until steady temperatures were reached.

It was found that the bearing and oil temperatures increased according to linear curves for engine speeds ranging from 1,500 r.p.m. to 4,000 r.p.m. All temperatures were higher when running in intermediate gears, the second-gear curve lying above the third-gear curve and this, in turn, lying above the top-gear curve. These results are clearly due to reduction in the speed of the car through the air when running in gear, engine speed being maintained constant. At an engine speed of 4,000 r.p.m., a reduction of car speed from 60 m.p.h. to 25 m.p.h. caused a rise in temperature of the oil in the sump of 17 deg. C., a rise in temperature of the bearings of 14 deg. C., and a corresponding rise of 7 deg. C. in the crankcase atmosphere. The result of varying the oil pressure was investigated in these road tests, and, as in the bench tests, the effect was found to be small. At 3,500 r.p.m., an increase of oil pressure of 55 lb. per square inch resulted only in a decrease of 4 deg. C. in the main bearing temperature, and 5 deg. C. in the big ends.

To investigate the effect of sump form on temperature rise, the standard unribbed sump, which had a capacity of 5¼ pints, was replaced by a sump of 10 pints capacity and with a certain amount of external ribbing. Both sumps were of cast aluminium. The bottom of the larger sump projected more into the air stream below the car and at 53 m p.h. its external surface temperature was found to be about 15 deg. C. lower than that of the original sump, and showed little variation over the speed range. Bearing and oil temperatures were unaffected by the change of sump, indicating that heat transfer from the oil to the sump is poor. The effect of the larger sump was, however, appreciable in delaying warming up. These effects suggested that increase in size of sump, rather than the adoption of external finning, may be an advantage.

The report considers the general indication of the tests to be that sufficient use is not being made, in standard designs, of the possibility of cooling the oi by conduction from the sump. With the original sump, the general car design blanked off the major portion of its outer surface from direct air blast. Some investigations into the possibility of improving sump cooling were carried out with the larger sump. A set of steel baffles, two longitudinal and two transverse, was made to extend within about ¼ in. of the sump bottom and to clear the sides by about the same amount. It was hoped in this way to force the oil into more intimate contact with the sump walls on its way to the pump intake. With this arrangement, at 53 m.p.h., the temperature of the outside of the sump was raised by 11 deg. C. and the big-end and main-bearing temperatures were reduced by about 7 deg. C. Insulating the sump from air cooling by means of asbestos sheets raised the outside wall temperature 40 deg. C.

# THE HOWELL-BUNGER DISCHARGE VALVE.

MESSRS. THE S. MORGAN SMITH COMPANY, YORK, PENNSYLVANIA, U.S.A.

*(For Description, see Opposite Page.)*

FIG. 1. VALVE IN CLOSED POSITION.

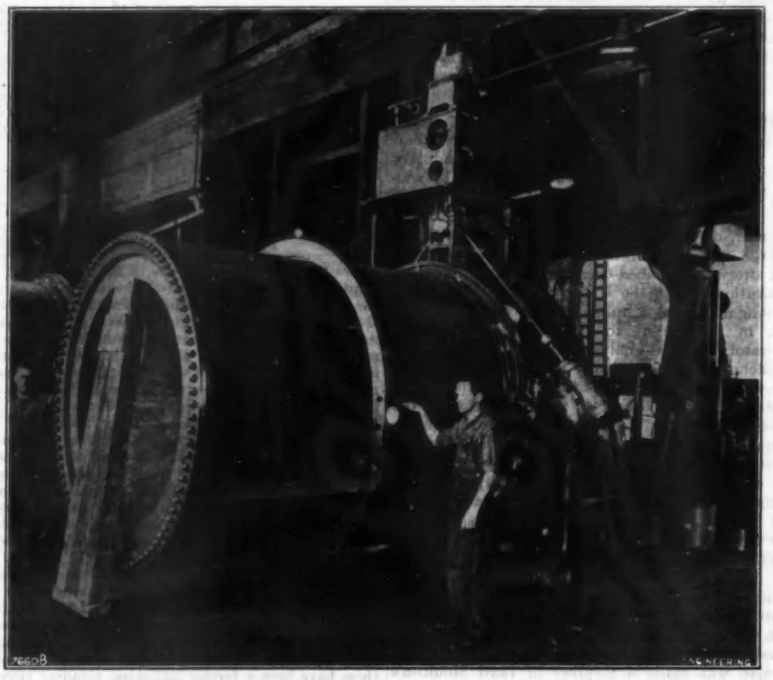

FIG. 2. VALVE FULLY OPEN.

## THE HOWELL-BUNGER HYDRAULIC DISCHARGE VALVE.

SIMPLICITY of parts, combined with a high discharge efficiency, appear to have been attained in the design of the Howell-Bunger balanced discharge valve which is made by Messrs. The S. Morgan Smith Company, York, Pennsylvania, U.S.A. The standard sizes of the valve range from 36 in. to 60 in., in 6-in. steps, but larger sizes are manufactured when required and three 96-in. valves have been installed recently at the Mud Mountain Dam, Washington; these are the largest yet built. The illustrations of one of these valves, given in Figs. 1 and 2, opposite, clearly show the compact nature of the design. The overall dimensions of the valve proper, apart from the operating gear, are, for a 36-in. valve, length 6 ft. 5 in., outside diameter of cylindrical casing 3 ft. 6¾ in., and width over operating lead-screws 7 ft. 8 in. The corresponding dimensions for the 96-in. valves are 12 ft. 5 in., 9 ft. 0½ in. and 13 ft. The standard valves are built for a head of 250 ft., but the large valves at the Mud Mountain Dam operate under a head of 340 ft. Valves in service have shown discharge coefficients as high as 96 per cent. at full gate, but it is usual to assume an efficiency of 90 per cent. when determining the size of valve required for any particular installation.

The valve consists of a cylindrical casing, or body, on the outside of which there is a sliding sleeve, or gate. The body, which is built up of steel plate, is provided with a flange at its upstream end, and by means of this connection is made to the penstock, the discharge of which is to be controlled. This flange can be seen at the right in Figs. 1 and 2. The form of the body is not well shown in these figures, as in each case it is partly masked by the sleeve. At the upstream end, for about half its length, it consists of a closed cylindrical wall, as can be seen to the right of the sleeve in Fig. 1. The other half length of the body is of open form, as shown at the left of Fig. 2, the construction providing a series of ports through which the discharge takes place. As will be seen, these ports occupy practically the whole circumference of the body, being separated from each other only by a series of radial ribs. These internal ribs extend the full length of the body and reinforce the cylindrical portion at the upstream end. They form a series of internal passages dividing the discharge into controlled streams. At the front end of the body, these ribs carry a cone, the outer surface of which directs the emerging streams of water away from each other and provides a spraying jet not likely to cause erosion below the valve site. The arrangement of the cone is clearly shown in Fig. 2. In Fig. 1, the valve is shown in the closed position, the sleeve covering the ports. In Fig. 2, the sleeve is moved back and the ports are open. It will be clear that the valve may be opened to any extent desired by regulating the position of the sleeve.

The sleeve, which in effect forms the valve gate, is operated by two lead screws driven by worm gears mounted on the body, as clearly shown in the figures. The screws engage nuts secured to the sleeve. The worm gears are connected by inclined shafts to bevel gears mounted on top of the body, and connected to the driving motor by a vertical shaft. As the valve is balanced, the main resistance encountered when the sleeve is moved is merely packing friction and consequently only a comparatively small motor is required. The 96-in. Mud Mountain valves can be opened or closed by a 15-h.p. motor in 7½ minutes. The surfaces over which the sleeve slides, that is, the edges of the ribs and the cylindrical part of the body, are faced with bronze. The upstream end of the sleeve is counterbored and is provided with graphite packing rings, which form an efficient seal between it and the body for any gate opening.

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WARNING TO ROAD-TRANSPORT OPERATORS.—The Minister of War Transport has issued a warning to road-transport operators to be on their guard against fifth columnists who, in the event of an invasion, might try to disorganise transport services by posting false notices or spreading false information. In a letter to associations asking them to call attention to this danger, the Minister makes four suggestions. In the first place, notices giving instructions to staff should be posted only inside premises at one, or at a strictly limited number of, well-defined points, which can be kept under constant supervision by the management. In the second place, instructions should on no account be posted outside premises or in any position accessible to unauthorised persons. Thirdly, employees should be warned to disregard any instruction, purporting to come from their employers, which may be posted in any other place than the recognised official notice board. Fourthly, they should be warned to satisfy themselves of the authenticity of any instruction conveyed to them in other ways.

## LABOUR NOTES.

THE *Ministry of Labour Gazette* states that in the industries for which statistics are regularly compiled by the Department, the changes in rates of wages reported to have come into operation in July resulted in an aggregate increase estimated at about 111,500*l.* in the weekly full-time wages of about 1,070,000 workpeople, while about 5,000 workpeople sustained a small decrease under the operation of cost-of-living sliding scale. The workpeople whose rates of wages were reduced had received increases of greater amount during earlier months of the year. Of the estimated total increase of 111,500*l.* a week, about 500*l.* was due to the operation of sliding scales based on fluctuations in the proceeds of the coal-mining industry, 25,500*l.* to arrangements made by joint standing bodies, 64,700*l.* to the operation of sliding scales based on the cost of living, and 16,100*l.* to arbitration awards. The remaining 4,700*l.* was the result of direct negotiation between employers and workpeople or their representatives. The whole of the estimated decrease —100*l.* a week—was due to the operation of sliding scales based on the cost of living.

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The changes reported in the first seven months of 1941 are estimated to have resulted in a net increase of about 1,400,000*l.* a week in the full-time wages of 7,100,000 workpeople. In the corresponding seven months of 1940, there was a net increase estimated at about 1,600,000*l.* in the weekly full-time wages of 7,150,000 workpeople. The particulars of numbers affected and amount of change in weekly wages, exclude changes affecting Government employees, agricultural labourers, shop assistants and clerks, for which classes the information available is not sufficient to form a basis for statistics. The estimates of the effects of the changes on weekly wages are based on normal conditions of employment, and do not take into account the effect of overtime working, etc.

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The Trades Union Congress at Edinburgh last week approved the reference, in the General Council's report, to the White Paper on the subject of wage policy. Sir Walter Citrine said that the problem went much further than was indicated in the White Paper, and the proposals which were offered were no solution. For the healthy government of the country, it was imperative that people should not get into the habit of looking to people above them to solve their problems. Wage increases had been inadequate; the cost of living had risen by approximately 30 per cent. and the average increase in war wages by 20 per cent. In these circumstances, stabilisation of wages would mean that they would be expected to accept a depressed standard of living for the rest of the war. The trade unions were, in his opinion, bound to resist any such conclusion. The General Council, Sir Walter added, were exploring any means whereby, while not only preserving the relative position of the workers and their relative share in the national pool of wealth, the share and their claim to it would be increased when the opportunity came in the post-war period to make it manifest.

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An emergency resolution, submitted on behalf of the General Council by Sir Walter Citrine, "hailed with satisfaction the alliance that has been formed with Soviet Russia", and endorsed the proposal, mentioned in the editorial Note on page 193, *ante*, to establish an Anglo-Russian Trade Union Council comprised of an equal number of representatives of the All-Union Central Council of Trade Unions of the Soviet Union and of the British Trade Union Congress General Council. This body, it was suggested, should hold regular meetings alternately in Russia and Great Britain for the exchange of views and information upon the problems with which the trade-union movement in each country was called upon to deal. An important proviso laid down, it was explained, was that in discussions and co-operation on matters of common concern there should be "the definite undertaking that there shall be no interference on questions of internal policy and organisation, which must remain the exclusive responsibility of each body." The resolution was carried without a dissentient voice.

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Sir Walter Citrine disclosed to the Congress that representatives of the General Council are to meet representatives of the Conservative Party for a discussion on the subject of the Trade Disputes and Trade Union Act, 1927. In a letter which he had recently received, he said, from the Prime Minister, Mr. Churchill had stated that, for his part, he would be willing to add the matter to the subjects which could be discussed after the war, but to raise the question of repeal of the Act in Parliament might result in differences which hampered the war effort. The General Council were anxious to avoid controversy, and, therefore, decided to limit their demands to the clauses of the Act which prevented civil servants and the officers of local authorities from becoming trade unionists. Eventually, they asked the Prime Minister, whether, if they were prepared to avoid raising political controversy, he would exercise a similar influence as leader of his party, and they suggested a meeting with representatives of the Conservative Party. As a result, the General Council had received information since coming to Edinburgh that arrangements were now in progress for such a meeting, and the General Council had appointed seven representatives for the purpose of carrying on the discussion.

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The action of the General Council was endorsed. Sir Walter Citrine said that he desired to make it clear that the General Council could not accept the *status quo* in any respect which tended to hamper the legitimate representations of Labour during the war. There was a Coalition Government—and they had a right to expect that some degree of satisfaction would be extended to the legitimate claims of the Labour movement.

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The number of trade disputes involving stoppages of work reported to the Ministry of Labour and National Service as beginning in July was 60. In addition five disputes which began before July were still in progress at the beginning of that month. The approximate number of workpeople involved in these 65 disputes (including workpeople thrown out of work at the establishments where the disputes occurred) was 16,500 and the aggregate duration of the disputes in July was about 25,000 working days. The aggregate duration of all disputes in progress during the first seven months of 1941 was about 720,000 working days and the total number of workpeople involved in these disputes was about 205,000.

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For the period of four weeks ended July 26 expenditure on unemployment allowances (excluding the cost of administration) amounted to approximately 325,000*l.* compared with 369,000*l.* during the four weeks ended June 28 and 948,000*l.* during the four weeks ended July 27, 1940. Comparison of the figures for June and July, 1941, with those for the corresponding months of 1940 is affected by an increase, in November, 1940, in the scale which forms the basis for the calculation of unemployment allowances.

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Agreement on the subject of conditions governing payment of the attendance bonus was reached at a further meeting last week of the Consultative Committee for the Coal Industry. It was originally stipulated that if a worker absented himself "without a proper cause" for one day he should sacrifice the bonus of 1*s.* a shift for the whole week. The miners strongly objected to the condition. Under the new arrangement, if a miner is absent from work on one day he will be penalised for that day only. An agreed statement issued at the close of the meeting was in the following terms:—"Realising that the fullest possible output of coal is of vital importance to the national war effort, it is agreed that the district and pit production committees shall co-operate fully in the production of coal, and that it shall be the responsibility of the district coal production committees to secure that machinery is set up at each pit which shall ensure that effective measures shall be taken at the pit to deal with any person whose conduct militates against the maximum possible production of coal."

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According to the Ministry of Labour and National Service, the number of men and boys registered at employment exchanges in Great Britain as wholly unemployed on August 11 was 116,127. Compared with July 14 this was a decrease of 3,273 among men and an increase of 5,378 among boys, the latter being mainly due to the registration of those leaving school. Of the total, 32,345 had been classified by interviewing panels as unsuitable for ordinary industrial employment. Those registered as on short time or otherwise temporarily suspended from work on the understanding that they were shortly to return to their former employment numbered 15,566; this was a decrease of 5,296 compared with July 14. Those registered as unemployed casual workers (being persons who normally seek their livelihood by jobs of short duration) numbered 11,982—an increase of 977 compared with July 14.

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The corresponding figures for women and girls on August 11, were 103,644 wholly unemployed, 22,384 temporarily stopped, and 586 unemployed casual workers. Compared with July 14, the numbers wholly unemployed showed a decrease of 6,644 among women and an increase of 4,373 among girls, the latter increase, as in the case of boys, being mainly due to the registration of those leaving school.

# THE ADMIRALTY EXPERIMENT WORKS, TORQUAY.*

By R. W. L. GAWN, R.C.N.C.

(*Continued from page* 200.)

AT the time of the founding of the Torquay Tank in 1871, a Committee on Designs of Ships of War recommended that provision of sail power in armoured ships with single screws was required for emergency and fuel economy only, and the area agreed upon was about three-fifths of that of the sailing ships of the line related to the usual Admiralty standard of (displacement)$^{\frac{2}{3}}$. For twin-screw ships, sail power was even more severely restricted. The Experiment Tank played a small part in connection with sail power in that William Froude gave, in 1876, a coefficient of 0·0017 $AV^3$ (lb. ft. sec. units) to supplement the many diverse coefficients in use at the time. Water-jet propulsion had attracted some attention, partly owing to Admiralty trials in the gunboat Water Witch in 1876, and again in 1881 in a torpedo boat, but the system did not find favour and was not subjected to tank tests at Torquay. Paddle-wheel propulsion, too, although favoured in many classes of merchant vessels, was not tested in the Tank, as it had been superseded by the screw propeller for H.M. ships long before 1871. A fair amount of useful information was available concerning the action and power of the screw propeller before the Tank was founded. Excellent work was done by some of the early pioneers of screw propulsion, and the task of the Tank was made lighter as a result. This early lead established by screw propulsion both in theory and design is still more or less maintained, compared with the associated subject of hull resistance. Substantial advance was recorded as a result of the propeller experiments at Torquay. The following brief review of the early ideas on propulsion is given in order that the progress rendered possible by the Tank investigations can be fully appreciated.

The screw propeller has been one of the most fruitful outlets of the resourceful brains of inventors. The early work of the Froudes clarified many aspects of propulsion, and the fallacy of many inventions and ideas was readily recognised; so that much needless full-scale trial and expense was saved, and at the same time a simple and ready means was provided for accurately testing any idea that seemed promising. It is said that the invention of the paddle wheel dates back to the Fifteenth Century, and in 1682 reference is found to a paddle tug used at Chatham Dockyard, actuated by a horse and gin; but it was not until 1822 that the Admiralty built a paddle tug, namely, the Comet, of Deptford. In 1832, the Admiralty fitted guns to the paddle steamer Salamander. The first practical steam ship, however, was the paddle stern wheel Charlotte Dundas, of 1802, and the first screw propeller, that of Edmund Shorter, fitted to H.M.S. Dragon in 1802. Later, on a transport ship, a speed of 1½ miles an hour was obtained. The propeller was worked by hand from the capstan. The early years of the Nineteenth Century were rich in paddle and screw-propeller inventions. Many names were associated with special forms of screw propeller, the most general for H.M. ships being Griffiths, Hirsch and Mangin propellers, each type of which had extensive trials. In 1838, the Archimedes, the first seagoing steamer to be fitted with screw propellers, was launched. This ship was 106 ft. long by 21·8 ft. beam, of 80 h.p., and steamed at 9·6 knots. The trials in 1840 satisfied the Admiralty of the advantages of screw propulsion, and the famous series of trials was initiated between the screw steamer Rattler and the paddle steamer Alecto, which were of similar lines apart from the screw aperture. Each ship was 176·5 ft. long by 32·7 ft. beam and 15·5 ft. draught (= 1,140 tons displacement) with engines of 200 n.h.p. Numerous exhaustive trials were carried out with different propellers, and under different conditions between 1843 and 1845 the most sensational being that in which the two ships were secured stern to stern. The screw-propelled Rattler eventually towed the Alecto astern at 2·8 knots. This was deemed a very crucial result and played an important part in the screw propeller being preferred to the paddle. Another extensive series of trials was made on H.M.S. Dwarf, and various other warships were tested with many different propellers from time to time, some of the tests including thrust measurements. By far the most important of these were on H.M.S. Iris in 1878. These were progressive trials, and included tests of propellers with two, three, four and six blades. As regards models, Mr. Charles Sells had tested an extensive series of propellers 6 in. in diameter over a range of pitch ratio from 0·75 to 2·25, generally at 250 ft. per minute and 2·27 lb. thrust. The effect of low pitch ratios down to 0·096 was also tested by Sells. Isherwood, in 1869 to 1870, also made some tests on larger propellers of 52 in. diameter on a steam launch 54 ft. long and of 8½ knots speed, equipped with thrust dynamometer and indicator. Mr. George Rennie, of the shipbuilding firm of that name on the Thames, carried out tests on the effect of immersion which, although open to certain objections, indicated some increase of thrust with increase of immersion. Immersion effect on cavitation was also investigated by Osborne Reynolds.* Professor Rankine, who played a leading part in developing ideas on resistance of ships and of streamline theory before Froude's experiment work, was also prominent in connection with propulsion. He gave the first fundamental propeller theory in 1865, and, although the practical reaction was small, the derived formulæ are not without interest and importance. In all these early trials the importance of the interaction between hull and propeller, although imperfectly understood, began to be appreciated. In many ships converted from sail to steam there was considerable power lost due to the full run and thick stern and rudder posts, but matters improved with experience to some extent. One example may be cited, namely, the extension of the stern by 10 ft. in the screw frigate Dauntless, in 1848, increased propeller efficiency and diminished revolutions, thereby effecting 30 per cent. reduction in the horse-power at full speed.

A general account of the investigations and results of propeller experiments at Torquay has been given in three important papers in the *Transactions* of this Institution. Some historical points are of interest. The first model propeller was tested behind the model of H.M.S. Encounter, a single-screw corvette, on August 15, 1873. This original model propeller is still available, and a photograph prepared for this paper is reproduced in Fig. 22, opposite. Fig. 23, on the same page, illustrates the last propeller made at Torquay in 1885. Sixty-one propellers were made there, and the photographs bear witness to the advance made. The propeller dynamometer had been completed some months previously, and was not only of William Froude's design, but, in part, his own handiwork. This dynamometer was used continuously at Torquay for 14 years, and was transferred to Haslar in 1886, where it continued in constant use until 1938, when it was replaced by more modern equipment. Sixty-five years of continuous service is a marvellous record of durability and capacity, particularly as the apparatus served for the discovery and elucidation of wake, augmentation of resistance, and other elements of propulsion, and the measurement of three important series of methodical series of screw propellers, as well as for tests on a variety of special propellers. The same equipment that served for the Encounter in 1873 was used for the battleship Hood in 1916, and also for fast destroyers and other modern ships. Screw experiments were not its only role. It was utilised for certain types of resistance experiment on submerged and other bodies, for tests to measure the resistance and lateral force on planes, and, until newer and more appropriate apparatus was introduced in the large tank nearly ten years ago, it was the instrument for testing submarines submerged, fast motor boats, and other craft which could not be conveniently connected to the main resistance dynamometer.

The early propeller experiments, in conjunction with the analysis of speed-trial results of ships and, in particular, that of the Iris, led directly to William Froude's last paper, and one of the most important dealing with the blade-element theory of propellers†; in addition to showing that, while a large diameter of propeller was advantageous in that a larger quantity of water was acted upon, the gain in this direction had to be balanced against the loss due to surface friction on the blades. This work of Froude's laid the sure foundation of propeller theory and, allied to the equally famous momentum theory published 14 years later by his son, constitutes substantially the modern theory of propeller action; elaborated and improved, but not fundamentally altered, by the mathematics of the circulation theory. This is a proud achievement when the extraordinarily large number of investigations and substantial progress in the 60 years since Froude's day is borne in mind. Curiously enough, this important paper was read without any discussion whatever, having suffered from the greater interest aroused by a previous paper by Mr. (later Sir) William H. White, concerning twin and single screws.

The first official report to the Admiralty addressed from the Haslar Establishment is dated March 27, 1886, and consists of a lengthy review of the propeller experiments at Torquay. It is recorded that the Torquay Establishment was finally closed down on January 31, 1886, and all experiments were suspended until March 22, 1887, when the first tests were made with newly installed equipment at Haslar. R. E. Froude devoted this interlude to the preparation of the propeller report referred to above, the revision of the skin-friction constants, the final evolution of the constant system of notation, and the standardisation of certain aspects of drawing-office practice and records of model results. The substance of the propeller report is given in the well-known paper* in the *Transactions* for 1886, which remained the most comprehensive investigation on screw dimensions and performance until superseded by another series, commenced 15 years later, but not published in the *Transactions* until 1908. R. E. Froude had found that the experiments at Torquay on model screws with different pitch ratios were not sufficiently systematic to afford information for determining the size of screws most favourable to efficiency, and the methodical series was accordingly put in hand and the results quickly published, by Admiralty permission, for general information. These tests were a great advance on any existing information. It is a striking commentary on the complexity of the propeller problem that, despite the advantage of 13 years of testing propellers and of the thought that the Froudes had given to the subject, the 1886 series contained two fundamental misconceptions, namely, that change of blade area had a negligible effect on performance, and that efficiency did not vary explicitly with pitch ratio apart from variation of slip. R. E. Froude was destined in his second series to modify these conclusions. These fallacies were of no importance in the days of the slow-running machinery of the 1880's, but attained considerable importance in the closing years of the Nineteenth Century, because of the growth in speed and the consequential evil of cavitation. Two points deserve special comment. First, the efficient elliptical blade outline was definitely established as superior to the varied and unsatisfactory shapes of many propeller blades. Second, the firm foundation was laid for the technique of model experiments as regards procedure and also the method of making model propellers. All the model propellers used in these tests are still in existence at Haslar. Some of the earlier ones are made of lead, but this was found too soft, and an alloy was substituted consisting of lead, tin, antimony, and bismuth. This is said to have been employed by William Froude after seeing the small metal models made by Sir Hamo Thornycroft, the sculptor. This material is still used for making small model propellers at Haslar, but other materials are preferred for larger propellers. The simple methods of moulding and casting initiated by Froude are still followed to some extent, but improvements in detail have been found necessary, particularly for the larger propellers, to give precision in finish. Froude's original submission to the Admiralty in December, 1868, included no proposals for propeller experiments, and Their Lordships' letter approving the Torquay experiments, dated February 1, 1870, provided for hull resistance and rolling experiments, but did not refer to propeller experiments. No record can now be traced of the circumstances which led to these propeller experiments being carried out, apart from a reference by William Froude of his intention, in a report to Admiralty in 1872. They were put in hand very soon after the Torquay Tank was erected and the immediate approved experiments completed.

While the existence of a wake stream in which the propeller works, together with the augmented resistance due to reduction of pressure on the after part of the ship by propeller action, were not by any means unknown before the Torquay model experiments were commenced, there was clearly much that was not understood and an almost complete absence of information concerning the magnitude and effect of the interaction between hull and propellers. True, there are references to the phenomena; for example, Phipps, in his Institution of Civil Engineers paper of 1863, refers to the screw propeller as "possessing the property of adding to the resistance"; and Rankine, in his 1865 Institution of Naval Architects paper, comments on the phenomena, as also does William Froude in his remarks on the latter paper. In the latter, Froude reveals a clear perception of the action, and refers to his experiments on clockwork models made some years previously, as showing that the augment of resistance is equal to about 50 per cent. of that of the hull resistance, but can be much reduced by moving the screw aft. In 1871 Froude showed, in his report on the Greyhound towing trials, that the indicated thrust is twice the resistance, suggesting that the propeller diminishes the hydrodynamic pressure on the after-lines of the ship and so increases the resistance. In 1877, however, in the discussion on Holt's paper on "Progress of Steam Shipping" before the Institution of Civil Engineers, Froude gave the first published description of his propeller experiments (he had briefly referred to them a year previously in a paper before the Institution of Naval Architects) and

* Paper presented to the Institution of Naval Architects. Abridged.

* "The Causes of the Racing of the Engines of Screw Steamers, investigated Theoretically and by Experiment." *Trans. I.N.A.*, vol. 14, page 56 (1873).

† "On the Elementary Relation between Pitch, Slip and Propulsive Efficiency." *Trans. I.N.A.*, vol. 19, page 47 (1878).

* "The Determination of the most suitable Dimensions for Screw Propellers." *Trans. I.N.A.* vol. 27, page 250 (1886).

remarked that, "assuming the ship to have an ordinary fineness of run, there was an augmentation of resistance of from 40 per cent. to 50 per cent." This enormous loss was well investigated and substantially reduced before the tests at Torquay were completed nine years later. The contribution of William Froude, although it implies the conception of wake, does not include any reference to it, and it was not until 1883 that wake and other relevant terms on the interaction of hull and propeller were defined in R. E. Froude's famous paper before this Institution. This enlarged on the earlier description of the propeller experiments by his father, and gave a complete account of the conception of the various hull-efficiency elements. These experiments had been proceeding for many years previously, but it is clear from the official reports that it was only shortly before the paper was produced that the final conception of the various qualities was developed. A curious matter of terminology arises in that, in the 1883 paper, R. E. Froude forsook the earlier description of "augmentation of resistance" for the use of the less obvious term "thrust deduction." He did not correct this until 1916, when he reverted to the original and more logical terminology, which has been followed in Admiralty practice since. The main principles of the system initiated by William Froude and elaborated by his son have continued in regular use; and, although the inner drive method is found necessary in certain types of warship, when a rudder or hydroplane would prevent the propellers from being mounted on an external frame, the outer drive method is preferred wherever possible, as giving a much greater variety of information more consistently and more expeditiously than the inner drive. These experiments on interaction between hull and propeller threw a flood of light on effect of size, variation, location, number of propellers, and shape of run on propulsion. Tests were also made on model hulls with rough surface, as a check on the frictional wake. R. E. Froude also referred to the turbulence of the wake found in his earlier experiments, noting that it would be informative to study this at a later date, but "not until other vastly more important investigations had been investigated." Turbulence still exists as a troublesome factor, and, although some investigation has been made into it as Froude suggested, there is still much to be discovered. Two matters in the discussion on the 1883 paper deserve attention; firstly, there was the recognition by R. E. Froude that application to ships might "baffle us," and secondly, the idea of a national tank for testing merchant ships was then first mooted, Lloyd's being suggested as the controlling authority.

The famous Greyhound trials were instituted by the Lords Commissioners of the Admiralty at the request of the Committee on Designs for Ships of War, and were carried out off Portsmouth in August and September, 1871, by William Froude. He and Mr. G. P. Bidder were appointed as a sub-committee to carry out the trials, but Mr. Bidder's other engagements only admitted of him devoting a small part of his time to this work. The complete results were reported to the Admiralty on March 31, 1873, and the substance of them given in a paper by William Froude in the *Transactions* in 1874. The investigation has been so fully described in this and other publications that comment would be unnecessary but for some results of model experiments, reported by Froude to the Admiralty on June 12, 1874. So far as can be traced by the author, these results have not previously been published, and as they have an important bearing on the conclusions drawn from the Greyhound trials, as well as being of general interest, they are included here. Their purpose is best described by the following verbatim extract from the introduction to the report.

"I have to report the result of two collateral, but not unimportant investigations which I have recently carried out—both of them relevant to the comparison between the Greyhound model and the Greyhound ship, but both having also a wider significance. In the first place, in testing the operation of parts of the apparatus for determining the augmented resistance due to screw action, it appeared that the presence of an independent body moving through the water astern of a model produced a sensible diminution of the model's resistance, even when the interval was unexpectedly large. This must have involved increased resistance to the independent body, and hence there appeared reason to suspect that some such mutual reaction between the towing ship Active and the towed ship Greyhound might have modified the true resistance of the latter. The object of one of these investigations was to test the existence or non-existence of such effect; and I may at once say it proves that this could not have existed to a sensible extent.

"In the second place, there has always seemed reason to surmise that a sensible augmentation of the Greyhound's resistance might have arisen from the comparative shoalness of the water in which the trials were made, the depth averaging about nine fathoms, or about four times the draught of the ship. The object of the second investigation was to test the truth of this surmise. It has proved that the surmise is correct, and has thus not only incidentally shown that the excess of the ship's resistance as compared with that calculated for the ship from the resistance of the model is very sensibly less than *prima facie* it had appeared to be, but also that the resistance of all large ships, tried for instance on the Stokes Bay measured mile, is, at full speed, more than 10 per cent. in excess of its true value."

A new model was made of Greyhound, one-twentieth full size instead of one-sixteenth that of the ship, as originally tried, the smaller model being more suitable to the intended experiments. It was confirmed that the results of the two models agreed when compared by the Law of Comparison, allowing for the surface friction correction. Another model was then rigged out from the dynamometer carriage to tow ahead and on one side of the Greyhound model in the same position to scale as that occupied by Active during the towing trials. This other model was that of the Shah, ballasted to the correct displacement for a model of Active. The effect on resistance of Greyhound model was "practically nothing," and Froude did not, therefore, regard it as necessary to test the Active.

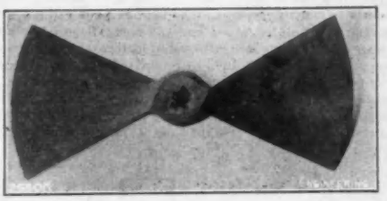


FIG. 22. SCREW PROPELLER, TORQUAY, 1873.

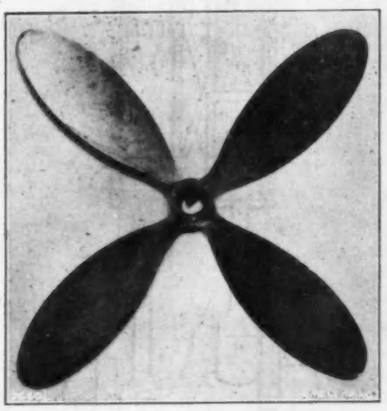
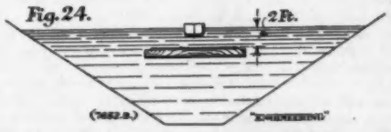


FIG. 23. SCREW PROPELLER, TORQUAY, 1885.




"Investigation No. 2 was carried out as follows:—A false bottom, or floor, was sunk in the waterway of the experiment tank, so arranged that it could be rigidly fixed at any required depth below the water surface, down to 6 ft. With a view to economy, the dimensions of the shoal were restricted to 60 ft. long by 9 ft. wide. [A cross-section of the tank showing the shoal in place and the smaller Greyhound model is given in Fig. 24, on this page.] With this 'shoal' set at a depth of 2 ft. below the surface (corresponding with 7 fathoms), the resistance of the Greyhound model at a speed of 250 ft. per minute (corresponding with 14 knots) was greatly increased at the moment of entering the shoal. The increase, however, was considerably reduced immediately afterwards. This was no doubt due to the fact that more force was required for the *setting up* of the change of streamline motions occasioned by the passage over the shoal than was required for the *maintenance* of the altered motions when established. Hence to get an accurate measure of the extra resistance involved in the passage of *continuously* shoal water, it became necessary in the analysis of these experiments to neglect certain portions at each end of the run over the shoal. This precaution was accordingly adopted throughout, but as it reduced not inconsiderably the length of run available for analysis, and as a very slight acceleration or retardation would in so short a run notably affect the apparent mean resistance, the experiments are, of course, rather less harmonious than the ordinary resistance experiments in open water. Still, as several experiments were made with each condition tried, the mean results are very fairly definite, and arrange themselves into tolerably harmonious sequences."

At 11¼ knots for the ship, the increase in resistance of the Greyhound model was 4½ per cent., and at 6·8 knots, 6½ per cent. "It will be seen by a reference to the Greyhound Report," wrote Froude, "that the application of such a correction to the curve of resistance calculated for the ship from the experiments with the model would considerably improve its agreement with the actual curve of resistance of the ship."

Table IV, herewith, abstracted from the report, shows the additional resistance in shallow water of 12 fathoms depth of ships of various sizes similar to the two models tried. The speeds 11·5, 15·0, 16·4 are "corresponding speeds" for the first three ships; and the speeds 10·0, 13·0, 14·3 are "corresponding speeds" for the last three. It was concluded that in 12 fathoms of water, which is the depth of the measured-mile courses at Portsmouth and Plymouth, the resistance of ships would be increased by about 10 per cent. as compared with deep water. A further quotation from the official report throws light on the general question of shallow-water effect as viewed by William Froude.

TABLE IV.—*Additional Resistance in Shallow Water.*

| Ship Type. | Displacement. Tons. | Speed. Knots. | Excess of Resistance. Tons. | Excess to Total Resistance. Per Cent. |
|---|---|---|---|---|
| 1,160-ton Shah .. | 1,160 | 11·5 | 0·1 | 2½ |
| Shah .. .. .. | 5,700 | 15·0 | 2·1 | 10 |
| 10,000-ton Shah .. | 10,000 | 16·4 | 4·6 | 12½ |
| Greyhound .. .. | 1,160 | 10·0 | 0·15 | 3 |
| 5,700-ton Greyhound .. | 5,700 | 13·0 | 2·3 | 10 |
| 10,000-ton Greyhound | 10,000 | 14·3 | 5·2 | 12½ |

"It should, however, be observed throughout that the augmentation indicated in all probability falls short of, rather than exceeds, the truth, since the comparatively narrow shoal with practically unlimited depth on either side which was used in these experiments must certainly have been less efficacious for augmentation than a shoal of wide extension. To make experiments upon many various models in shoal water would involve more delay than I should think it wise to incur at present, and I think it probable that theoretical considerations may develop from these experiments as they stand some general expression which may evaluate the effect accurately enough for a ship of any ordinary form.

"I think this is the more probable because the phenomenon in this case is clearly not one of wave action in any sensible degree, for the diagrams show that the excess of resistance caused by a given shoal increases pretty truly as the square of the speed and not in any higher ratio, and indeed is very fully developed at low speeds at which no waves at all are made. It is no doubt true the very great 'drag' which high-speed boats experience in travelling very shoal water is manifestly accompanied by a great heightening of the companion waves, yet this only occurs at speeds much higher, compared with the depth of water and the size of the vessel, than those dealt with in these experiments, and the visible magnitude of the waves, and the excessive increase of resistance, alike cease with a comparatively small reduction of speed. In fact, according to the received theories of wave motion, the effect of a shoal 2 ft. or even 1 ft. 6 in. in depth upon waves having the slow speeds dealt with in these experiments would be scarcely perceptible.

"Nevertheless, it is certain that in these experiments there resulted a very considerable increase in the resistance of the models, and this I believe to be due to two causes:—(1) in a small degree to the increase of surface friction consequent on the increased sternward speed which the construction of the channel impresses on the water surrounding the model; (2) but, principally, to the greatly increased distortion of the stream-lines causing increased friction mutually between the particles of water, and consequently a less perfect replacement of water behind the model. The effect due to each of these causes I believe should be approximately proportional to the square of the speed, and both can, I think, be dealt with by mathematics with sufficient accuracy for our present purposes. P.S.—It is perhaps right to mention that the depth of the experiment tank in its working condition (10 ft.) is relatively so great that in relation to our ordinary experiments

it may be regarded as unlimited, it is in effect equivalent on an average to 30 fathoms."

In some cases, Froude's rational argument that the effects are underrated by the conditions of the model test has not been borne out by trial results. In recent years, a complete series of tests in shallow water for various types of ship, as envisaged by Froude, has been carried out in the large tank at Haslar. Although a model as bluff as Greyhound, as regards the large proportion of displacement to length, was not tried, yet an extrapolation of the results obtained shows that Froude's percentage increases in shallow water are not unreasonable. Much attention has rightly been concentrated on the amount by which the resistance of Greyhound with varnished surface, deduced from the model experiments, fell short of the measured resistance—about 12 per cent. at 11 knots. This difference is reduced to about 8 per cent. by the results of the shallow-water experiments, and the case for the Law of Comparison is to this extent strengthened.

*(To be continued.)*

## CATALOGUES.

*Heating Stoves.*—Messrs. Tangyes, Limited, Cornwall Works, Birmingham, have sent us a pamphlet dealing with their factory-heating stove. The firebox is of square section permitting the use of rectangular firebricks.

*Kitchen Equipment.*—Messrs. The English Electric Company, Limited, Queen's House, Kingsway, London, W.C.2, have sent us leaflets relating to kitchen equipment for heavy duty in hotels, restaurants and canteens.

*Electrode Heating and Soldering.*—We have received from Messrs. Stanelco Products, Ferndown, Northwood Hills, Middlesex, a brochure describing their electrode equipment for heating and soldering, which is operated by hand or foot.

*Wear-Resisting Alloys.*—We have received from Messrs. A. S. Young and Company, Limited, Tower Works, Woodside-lane, North Finchley, London, N.12, particulars of Colmonoy hard facing alloys, which have been developed to resist abrasion and corrosion.

*Metal Spraying.*—We have received from Messrs. Metallisation, Limited, Barclay's Bank Chambers, Dudley, a booklet which describes their process of building up worn parts of machinery by metal spraying. Particulars are given of tests on parts so treated.

*Face Milling and Filing Machines.*—A leaflet received from Messrs. Lorant and Company, Limited, 98-100, Croydon-road, London, S.E.20, describes the "Rindis" machine for face milling and filing, and also machines for reaming, lapping, grinding and countersinking.

*Welding.*—Messrs. Barimar, Limited, Barimar House, 22-24, Peterborough-road, Fulham, London, S.W.6, have sent us a pamphlet dealing with their service for the repair of broken machine parts by low-temperature welding, and illustrating a variety of work successfully carried out.

*Dust Removal and Collection.*—Messrs. Davidson and Company, Limited, Sirocco Engineering Works, Belfast, have sent us a brochure, No. SF343, dealing with the removal and collection of dust from woodworking machines, the use of wood refuse as fuel, and the application of "Sirocco" equipment to timber drying. Fume-removal plant for paint-spraying booths is also described, and a useful folding data sheet is appended, giving the principal characteristics of some 70 Empire timbers.

TYRES FOR MOTOR VEHICLES.—The Minister of War Transport has advised all owners of motor vehicles to look to their tyres in order to make them last as long as possible. He points out that new tyres are needed in increasing numbers for the Fighting Services and the supply for civilian purposes, during the next twelve months, is likely to fall considerably short of requirements. The longest mileage from tyres is obtained by removing them for remoulding or retreading while they are still in a suitable condition and before the wear on the casings is too heavy.

THE LATE MR. C. H. COX.—The news of the death of Mr. Charles Horace Cox, which occurred on August 2 as a result of a riding accident on his farm in Wiltshire, will be received with regret by many electrical engineers in this country. Mr. Cox, who was in his sixty-fifth year, had been a director of Messrs. Edison Swan Electric Company, Limited, for some 20 years, and was also a director of Messrs. Edison Swan Cables, Limited. He was a past chairman of the British Electrical Development Association and, at the time of his death, was a member of the Electrical Lamp Manufacturers' Association of Great Britain, Limited. In his youth he served in the Boer War of 1899-1902 and afterwards remained in South Africa for a time as deputy District Commissioner at Ermelo in the Eastern Transvaal.

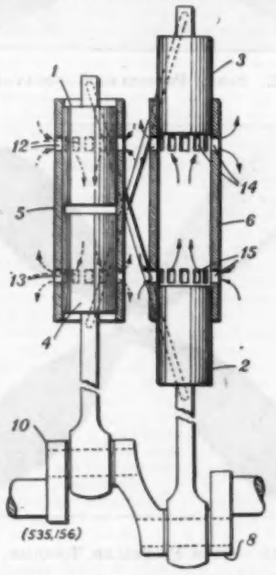
## "ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

*The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.*
*Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.*
*Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.*
*The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.*
*Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.*

### INTERNAL-COMBUSTION ENGINES.

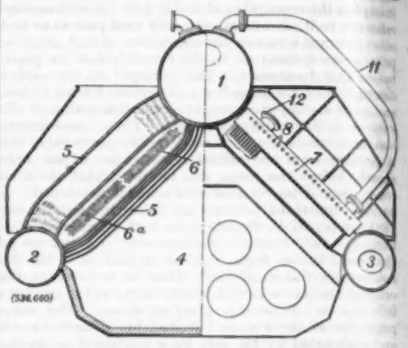
**535,156. Fullagar Opposed-Piston Engine. The English Electric Company, Limited, of London, and G. H. Paulin and R. J. Welsh, of Rugby.** (1 *Fig.*) February 8, 1940.—Hitherto in arrangements of Fullagar engines such as that shown, the ports 12 and 14 have been the inlet ports, while the ports 13 and 15 have been the exhaust ports, the scavenging air flowing downwards in both cylinders. The cranks have always been at 180 deg. to each other and the ports disposed so that the exhaust ports are uncovered before the inlet ports and are not covered until after the inlet ports. According to the present invention the ports 12 are inlet ports while the ports 14 are exhaust ports. Similarly, the ports 13 are exhaust ports while the ports 15 are inlet ports. Hence, the two pistons 1 and 2 uncover the




inlet ports in both cylinders while the pistons 3 and 4 uncover the exhaust ports in both cylinders. The scavenging air flows downwards in cylinder 5 and upwards in cylinder 6. The exhaust ports in each cylinder are uncovered well before the inlet ports are uncovered. The cranks can be at 180 deg. to each other as hitherto, but any advance of the crank 10 relatively to the crank 8 will increase the angle of advance of the opening of the exhaust relative to the air inlet, and will at the same time decrease the angle by which closing of the exhaust lags behind the inlet. Accordingly, by varying the angle between the two cranks it can be arranged that the exhaust opens very considerably in advance of the inlet and closes substantially simultaneously with or even before the inlet. (*Accepted March* 31, 1941.)

### STEAM ENGINES, BOILERS, ETC.

**536,660. Water-Tube Boiler. John I. Thornycroft and Company, Limited, of Westminster, and Eng. Capt. G. Villar, R.N., of Southampton.** (3 *Figs.*) January 3, 1940.—The water drums 2, 3 at opposite sides of the combustion chamber 4 are connected in the normal manner to the steam and water drum 1 by steam generating tubes 5. Between groups of the steam generating tubes at each side of the combustion chamber are two groups of superheater tubes 6 and 6a, with their axes slightly inclined. The ends of the tubes are expanded into headers 7. Each header has a number of holes 8 along the side opposite to the superheater tubes, the holes being closed by detachable doors. To each header associated with the group 6a of the superheater tubes at one end of the boiler is connected a pipe 11 by which saturated steam is led from the upper drum while the headers associated with the group 6 at the same end of the boiler each have an outlet 12 for superheated steam. By arranging the superheated tubes at a slight inclination it is ensured that all the air is evacuated




during the complete filling of the boiler with water. On removal of the doors in the headers, the internal surfaces of all the superheater tubes can be sighted and cleaned over their entire length, and also any superheater tube may be replaced while the headers are in position. (*Accepted May* 22, 1941.)

### MISCELLANEOUS.

**535,645. Photographing Motion-Picture Titles. Kodak, Limited, of London.** (5 *Figs.*) August 11, 1939.—The invention is a copying apparatus employing a motion-picture camera for recording titles mounted on an easel. The apparatus consists of a bed which is U-shaped in transverse section to provide a pair of side rails 13 at one end of which a title easel 14 is fixed. A camera carriage 16 runs on pinions 18, which engage racks on the top of the side rails 13. A handle 20 drives the pinions. The title to be recorded is placed on the easel 14, and a motion-picture camera is mounted on the carriage 16. Upon movement of the carriage towards or away from the title easel, the camera moves through a range of fields of various widths. To retain the titles in focus, a supplementary collimating lens system is used, which consists of a fixed positive lens mounted in a lens tube 36 and a negative lens secured in a sleeve sliding in the tube. The lens tube 36 is mounted in a lens holder,

Fig. 1.

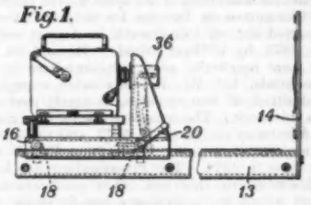
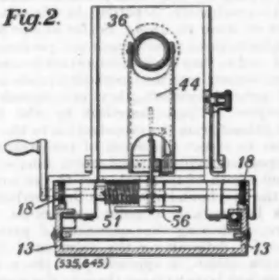



Fig. 2.




which also carries a pivoting arm 44 (Fig. 2), the upper end of which is pinned to the sleeve. A worm 51 on the pinion shaft drives a camshaft carrying a cam 56. A lever freely mounted on the pivot shaft of the arm has one end engaging the cam, while the other end engages the back of the lens-moving arm. The lever is held in contact with both the arms and the cam by springs. By this arrangement, the movement of the negative lens is controlled so that the lens system for the camera is always in focus on the easel 14. In addition, the arrangement has other advantages. Thus, the spring lever connection between the cam 56 and the arm 44 allows the focus of the lens system to be fixed, in which case the camera will be in focus for only one position of the carriage. In this case, on moving the carriage the title can be gradually brought into focus, and then gradually faded out of focus. (*Accepted April* 16, 1941).